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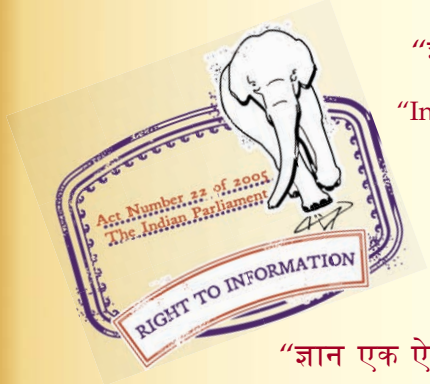
IS 7405-1 (1994): printed wiring boards, Part 1: General requirements and methods of test [LITD 5: Semiconductor and Other Electronic Components and Devices]



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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 7405 (Part 1) : 1994
(Reaffirmed 2002)

भारतीय मानक

मुद्रित तार स्थापन बोर्ड की विशिष्टि

भाग 1 सामान्य अपेक्षाएँ और परीक्षण पद्धतियाँ

(दूसरा पुनरीक्षण)

Indian Standard

SPECIFICATION FOR PRINTED WIRING BOARDS

PART 1 GENERAL REQUIREMENTS AND METHODS OF TEST

(Second Revision)

First Reprint SEPTEMBER 1995

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Price Group 11

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Printed Circuits Sectional Committee, LTD 17

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Printed Circuits Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

This standard was first published in 1973 and revised in 1983. The second revision is being revised to update it with latest developments in the field of manufacture and use of printed circuits.

While preparing this draft Indian Standard, assistance has been derived from the following IEC Pub/ Amendment/Supplement/Document:

Second supplement to IEC Pub 326-2 (1976) — Printed boards : Part 2 Test methods

Amendment No. 2 (1988) — Amendment No. 2 (Jan 1988) to Pub 326-2 (1976)

IEC Doc 52 (C. O.) 309 — Draft Amendment to Pub 326 : Printed boards : Part 2 Test methods : Test 15b : Microsection

IEC Doc 52 (C. O.) 301 — Draft Amendment to Pub 326 : Printed boards : Part 2 Test methods : Test 4a : Short circuits

IEC Doc 52 (Sectt) 294 — Additions to Pub 326-2 : Printed boards : Part 2 Test methods : Test 22 Ionic surface contamination test

issued by the International Electrotechnical Commission.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SPECIFICATION FOR PRINTED WIRING BOARDS

PART 1 GENERAL REQUIREMENTS AND METHODS OF TEST

(Second Revision)

1 SCOPE

1.1 This standard (Part 1) specifies general requirements and methods of test for printed wiring boards irrespective of their method of manufacture, when they are ready for mounting of components.

2 TERMINOLOGY

2.1 For the purpose of this standard, the definitions of terms as given in IS 1885 (Part 6) : 1978 'Electrotechnical vocabulary : Part 6 Printed circuits' shall apply.

3 MATERIALS

3.1 The printed wiring boards shall be manufactured from suitable materials which shall conform to relevant Indian Standards.

4 CATEGORY

4.1 The printed wiring boards may be categorised by the environmental severities that they can withstand. These categories shall be sppecified in the detail specifications.

5 MARKING

5.1 Each board shall be legibly and indelibly marked with the date and manufacturer's code. The marking shall be produced either by the same process used in producing the conductor pattern or by the use of a permanent non-nutrient ink or paint conductive markings shall be not closer to the pattern than the spacing requirements specified for conductor. All marking shall be compatible with materials and parts, legible after all tests and shall in no case effect board performance.

5.1.1 Marking indicating the pattern designation shall be as agreed to between the purchaser and the manufacturer or the supplier.

5.2 BIS Certification Marking

The product may also be marked with the Standard Mark.

5.2.1 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

6 CLASSIFICATION OF TESTS

6.1 Type Tests

The procedure for type approval shall be in accordance with IS 10673 : 1983 'Sampling plans and procedures for inspection by attributes for electronic items'. Unless otherwise specified, the manufacturer shall supply 7 printed wiring boards of each category and also 7 number of boards etched to the standard pattern processed along with the normal production.

The tests shall be carried out preferably on production boards but if required, test coupons etched with composite test pattern may be used. The composite test pattern shall be specified in the detail specifications.

6.2 Acceptance Tests

Unless otherwise specified the acceptance tests shall be carried out on a limited number of samples selected in accordance with the sampling procedure of IS 10673: 1983 'Sampling plans and procedures for inspection by attributes for electronic items' and which have passed the routine tests.

6.3 Routine Tests

All the printed wiring boards shall be subjected to general examination. Additional tests may be agreed upon by the purchaser and the supplier and may be carried out in the presence of the purchaser.

7 CONDITIONS FOR TESTS

7.1 Standard Atmospheric Conditions for Testing

Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions, as specified in IS 9000 (Part 1) : 1977 'Basic environmental testing procedures for electronic and electrical items: Part 1 General'.

The ambient temperature and the relative humidity at which the measurements are made shall be stated in the report.

In case of dispute between the purchaser and the vendor about test results, the tests shall be carried out at one of the 'referee conditions' of IS 9000 (Part 1) : 1977 'Basic environmental testing procedures for electronic and electrical item: Part 1 General'.

7.2 Test Specimen

If possible and unless otherwise specified, the test shall be carried out on production board. Test coupons may be necessary or desirable for certain tests. Test coupons may be included on the panel with the production boards or may be produced as separate composite test coupons in conjunction with the production boards with the same materials and processes so as to be representative of the production boards. If separate composite test coupons are manufactured, they shall be spaced out evenly in production in such a quantity that a good average assessment can be made.

8 LIST OF TESTS

8.1 All the tests given in this standard are enumerated in Table 1 with clause references.

Table 1 List of Tests

(*Clause* 8.1)

Test No.	Test	Clause No.
	General Examination	9
1	Visual examination	9.1
1a	X3 Magnification method	9.1.1
1b	X10 Magnification method	9.1.2
1c	X250 Magnification method	9.1.3
2	Dimensional examination	9.2
2a	Optical method	9.2.2
	Electrical Tests	10
3	Resistance	10.1
3a	Resistance of conductors	10.1.1
3b	Resistance of interconnections	10.1.2
3c	Change in resistance of plated-through holes, thermal cycling	10.1.3
4	Electrical integrity	10.2
4a	Circuit isolation	10.2.1
4b	Circuit continuity	10.2.2
5	Current proof	10.3.
5a	Current proof, plated through holes	10.3.1
5b	Current proof, conductors	10.3.2
6	Insulation resistance	10.4
6a	Insulation resistance, surface layers	10.4.1
6b	Insulation resistance, internal layers	10.4.2
6c	Insulation resistance, between layers	10.4.3
7	Voltage proof	10.5
7a	Voltage proof, surface layers	10.5.1
7b	Voltage proof, between layers	10.5.2
8	Frequency drift	10.6
9	Circuit impedance	10.7
	Mechanical Tests	11
10	Peel strength	11.1
10a	Peel strength, standard atmospheric conditions	11.1.1
10b	Peel strength, elevated temperature	11.1.2
10c	Peel strength, flexible printed board	11.1.3
11	Pull-off strength	11.2
11a	Pull-off strength, lands with plain holes	11.2.1
11b	Pull-out strength, landless plated through holes	11.2.2
12a	Flatness	11.3
21a	Flexural fatigue (flexible printed boards)	11.4
	Miscellaneous Tests	12
13	Plating finishes	12.1
13a	Adhesion of plating, tape method	12.1.1
13b	Adhesion of plating, burnish method	12.1.2
13c	Porosity, gas exposure	12.1.3
13d	Porosity, electrographic test, gold on copper	12.1.4
13e	Porosity, electrographic test, gold on nickel	12.1.5
13f	Thickness of plating	12.1.6
14a	Solderability	12.2
15a	Delamination, thermal shock	12.3
15b	Microsection	12.4
16a	Flammability, rigid printed boards, metal removed	12.5
16b	Glow-wire test, printed boards	12.5.2
16c	Needle-flame test, rigid printed boards	12.5.3

Table 1 (*concluded*)

Test No.	Test	Clause No.
17a	Solvent and flux resistance	12.6
22	Ionic surface contamination test	12.7
23	Outgassing test of plated through holes environmental conditioning	12.8
18	Preconditioning	13.1
18a	Preconditioning, standard atmospheric conditions	13.1.1
18b	Preconditioning, 125°C	13.1.1
19	Thermal shock	13.2
19a	Thermal shock, immersion, oil bath	13.2.1
19b	Thermal shock, immersion, fluidized and bath	13.2.2
19c	Thermal shock, floating, solder bath	13.2.3
19d	Thermal shock, hand-soldering	13.2.4
19e	Thermal shock, dip-soldering	13.2.5
19f	Thermal shock, floating, solder bath 280°C	13.2.6
20a	Accelerated ageing	13.3

9 GENERAL EXAMINATION

9.1 Test 1 : Visual Examination

The visual examination checks identification, appearance, workmanship, finish, pattern, etc, of a printed board against the relevant specification by viewing with or without use of magnification.

9.1.1 *Test 1a: X3 Magnification Method*

The visual examination shall be carried out using optical equipment with approximately X3 linear magnification and where possible transmitted light.

9.1.2 *Test 1b : X10 Magnification Method*

When specified, the visual examination shall be carried out using optical equipment with approximately X 210 linear magnification and where possible transmitted light.

9.1.3 *Test 1c : 250 Magnification Method*

When specified, the visual examination shall be carried out using optical equipment with approximately X 250 linear magnification. This is usually required for microsection.

9.2 Test 2 : Dimensional Examination

The dimensional examination is the measurement of actual dimensions with the aid of measuring tools and measuring equipment against the relevant specification.

9.2.1 The measuring tools and equipment shall have an accuracy and readability suitable for the dimensions and tolerance to be measured.

9.2.2 *Test 2a : Optical Method*

When specified, particular measurements, for instance, on dimensions of holes and edge defects in conductors, shall be measured with an optical instrument having a measuring recticule and a readability of 0.025 mm.

9.2.3 When specified, particular measurements, for instance, flatnesss of printed boards, shall be carried out using gauges as specified under the test method and/or the detail specification.

10 ELECTRICAL TESTS

10.1 Test 3 : Resistance

10.1.1 *Test 3a : Resistance of Conductors*

10.1.1.1 *Object*

To determine the resistance of conductors.

10.1.1.2 *Specimen*

The measurement shall be carried out on specified conductors. These conductors shall be as long and narrow as possible.

10.1.1.3 *Method*

The resistance shall be measured using a suitable method on two conductors at two places. The measuring error shall not be greater than 5 percent. The current shall be kept small enough, preferably 0.1 A, to avoid heating the specimen appreciably. In case of dispute, a four-terminal method shall be used.

10.1.1.4 *Details to be specified* :

a) conductors to be measured,

b) value of the resistance, and

c) any deviation from the standard test method.

10.1.2 *Test 3b : Resistance of Interconnections*

10.1.2.1 *Object*

To determine the resistance of interconnections on a printed board.

10.1.2.2 *Specimen*

The measurement shall be carried out on specified parts of a production board, of a test coupon or of a composite test coupon.

10.1.2.3 *Method*

The resistance shall be measured with a four-terminal method of equivalent method between two specified holes. The measuring current shall not exceed 0.1 A. The total measuring error shall be less than 5 percent.

Two typical connection methods are shown in Fig. 1 and 2.

a) Leads are soldered into the specified holes according to Fig. 1.

b) The connections are made using two pairs of contact pins according to Fig. 2.

NOTE – Two of the test probes as described in Test 5a are suitable (*see* Fig. 4).

10.1.2.4 *Details to be specified :*

a) Holes and interconnections to be measured,

b) Connection method,

c) Maximum value of the resistance, and

d) Any deviation from the standard test method.

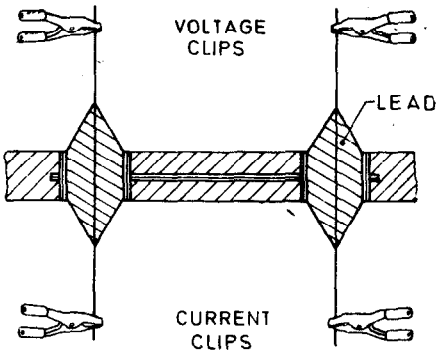


FIG. 1 MEASUREMENT OF RESISTANCE WITH SOLDERED LEADS

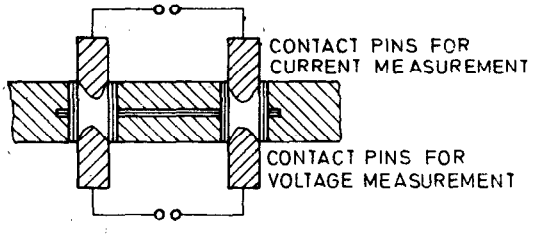


FIG. 2 MEASUREMENT OF RESISTANCE WITH CONTACT PINS

10.1.3 *Test 3c : Change in Resistance of Plated – Through Holes, Thermal Cycling*

10.1.3.1 *Object*

To determine the increase in resistance of plated through holes that may occur when the holes are subjected to thermal cycling, by monitoring the resistance continuously during the test.

The increase gives an indication of the quality of the plating.

10.1.3.2 *Specimen*

The test shall be carried out on a suitable printed board having a number of plated-through holes connected in series.

The test board shall preferably not be tin-lead plated. If it is, the plating shall be chemically removed prior to testing but care shall be taken to avoid any detrimental effect to the copper.

NOTE – A suitable remover consists of :

- 330 ml nitric acid 60 percent (density 1.36 g/cm^3 at 20°C);
- 3 ml fluoroboric acid 40 percent (density 1.32 g/cm^3 at 20°C); and
- 670 ml deionized water.

When using removers, the necessary precautions shall be taken to avoid any injury to health.

10.1.3.3 *Method*

The resistance (or the corresponding voltage drop) of the holes connected in series shall be measured at a constant measuring current of 100 ± 5 mA using the four-terminal method. The resistance shall be monitored continuously during the test. The specimen shall be connected to the recording device by, for example, a suitable edge-board connector.

The thermal cycling shall be carried out by using following two separate fluid baths alternately:

a) An ambient temperature bath, as specified in **13.2.1** Test 19a, but kept at the temperature of 25 ± 2°C; it is essential for efficient cooling that the bath at 25°C should contain a low viscosity fluid.

b) A hot bath as specified in **13.2.1**, Test 19a kept at the temperature of 260 $^{+5}_{-0}$ °C.

The specimen shall be immersed in the fluid vertically to a depth which leaves the area of connection, for example, the edge board connector, approximately 30 mm above the surface of the fluid. To improve the heat transfer during the immersion in the hot fluid, the specimen should be slightly moved (in a horizontal direction parallel to its surface). After immersion and withdrawal from the 25°C bath, the fluid remaining on the test panel shall be removed before the next immersion.

The specimen shall be immersed alternately in the 25°C bath and in the 260°C bath. The cycling begins and ends with an immersion in the 25°C bath. The specimen must be transferred from the 260°C bath into the 25°C bath without time delay.

The total number of immersions shall be as specified. The specimen shall remain in the 25°C bath until a stable reading of the resistance is obtained. The specimen shall remain in the 260°C for a period of 20°C ± 1 s. If the characteristics of the base material used require it, slightly different immersion times may be specified in the relevant specification or agreed upon between the purchaser and the vendor.

The resistance value (or the corresponding voltage drop) is plotted on a time scale against the number of immersions. The diagram resulting, for example from a chart recorder, has an aspect similar to that shown in Fig. 3.

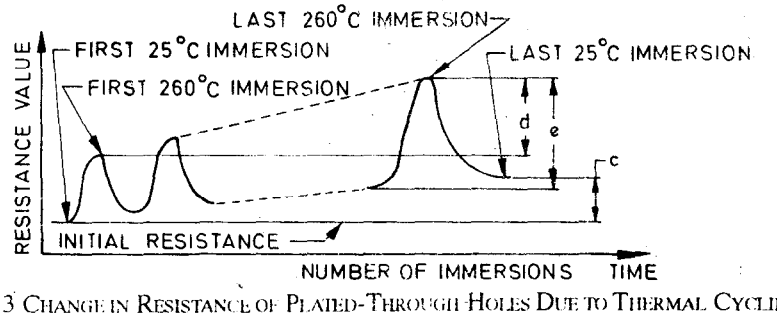


FIG. 3 CHANGE IN RESISTANCE OF PLATED-THROUGH HOLES DUE TO THERMAL CYCLING

10.1.3.4 *Details to be specified :*

a) Specimen to be tested;
b) Number of 260°C immersions;
c) Maximum permissible increase in percent of resistance between the first and the last 25°C immersion;
d) Maximum permissible increase in percent of resistance between the first and the last 260°C immersion;
e) Maximum permissible increase in percent of resistance during any one 260°C immersion; and
f) Any deviation from the standard test method.

10.2 Test 4 : Electrical Integrity

Electrical integrity shall be established by two (2) test procedures – Test 4a: Circuit isolation and Test 4b: Circuit continuity. These tests may be combined in order to be accomplished one after the other on the same specimen.

The application of a common value of current as a limiting condition (that is, as border-line between circuit isolation conditions and circuit continuity conditions) as well as the use of automatic test equipment may facilitate the combination.

These tests are not intended to substitute for visual inspection (Test 1a).

10.2.1 *Test 4a : Circuit Isolation*

10.2.1.1 *Object*

To verify the absence of conductive connection between specified parts of a conductive pattern of a printed board that were intended to be unconnected, in accordance with the relevant specification (that is, artwork, customer requirements, computer aided data, etc).

10.2.1.2 *Specimen*

The test shall be carried out on specified portions of conductive patterns on or between any layers of production boards.

10.2.1.3 *Method*

The specified points of each separately accessible circuit of the conductive pattern shall be connected to the test source by suitable means, for example, by test probes contacting the specified conductors or lands. The remaining circuits, not under test, may be connected together, connected as groups in turn, or tested each in its turn.

Where appropriate, multiple arrangements of test probes may be used (that is, bed of nails, ± /C pattern probe, etc), where a printed board contains edge board contacts, they may also be used together with a suitable edge socket connector.

A specified ac or dc test voltage shall be applied to parts of the conductive pattern under test, so that a current will flow if a short circuit is present. The source of the test voltage shall be associated with the means for monitoring delivered current and limiting the current to a value to be within the current carrying capacity of the circuit under test in order to avoid over-heating.

A quick evaluation for short circuits may be made using a simple indicator, such as an indicator lamp or measuring instrument or by an electrical circuit transforming the current into a signal which may be evaluated by an automatic test equipment.

For sophisticated evaluation of short circuits, the current shall be monitored in such a fashion as to enable the value of ohmic resistance existing between separate conductive patterns to be determinable within a measurement uncertainty not exceeding 100% at the minimum value of resistance given as the limiting requirement for circuit isolation.

There shall be no short circuits between specified points. When evaluating specific requirements, circuit isolation is deemed to be maintained when the value of resistance represented by any current flowing between separate conductors under test is greater than 1 megohm, or as otherwise specified in the customer's detail specification.

10.2.1.4 *Details to be specified :*

a) Test voltage,
b) Minimum allowable resistance if other than 1 megohm,
c) Part(s) of conductive pattern to be tested,
d) Allowable maximum current, and
e) Any deviation from the standard test method.

10.2.2 *Test 4b : Circuit Continuity*

10.2.2.1 *Object*

To verify the establishment of electrical continuity through the specified connected points of a conductive pattern of a printed board in accordance with the relevant specification (that is, artwork, customer requirements, computer aided data, etc).

10.2.2.2 *Specimen*

The test shall be carried out on specified portions of the conductive patterns on or between any layers of the production board.

10.2.2.3 *Method*

The specified points of the conductive patterns shall be connected to the test circuit by any suitable means, for example, by test probes contacting the specified conductors or lands. Where appropriate, multiple arrangenents of test probes may be used. Where a printed board contains edge board contacts, they may also be used together with a suitable edge socket connector.

A specified ac or dc voltage shall be applied to each separately connected conductive path in turn, across any externally accessible circuit connection point (for example, land, edge connector contact) and sequentially to each other external connecting point to which it is intened to be connected.

A quick evaluation for circuit continuity may be made using a simple indicator, such as an indicator lamp or measuring instrument or by an electrical circuit transforming the current into a signal which may be evaluated by an automatic test equipment.

For sophisticated evaluation of circuit continuity, the resultant current flow in each path shall be monitored in such a fashion as to enable the value of ohmic resistance existing between any points within the circuit to be determinable within a measurement uncertainty not to exceed 100% at the maximum value of resistance given as the limit requirement for circuit continuity.

Arrangements shall be employed to limit the maximum current to be within the current carrying capacity of the circuits under test.

There shall be electrical continuity between all specified points of each circuit. For sophisticated equipment, the circuit continuity is deemed to have been established when the value of resistance represented by the current flowing between any points in the circuit is less than 5 ohms, or whichever single value is specified in the customer detail specification.

10.2.2.4 *Details to be specified*:

a) Test voltage ;
b) Maximum allowable resistance, if other than 5 ohms;
c) Part(s) of conductive pattern to be tested;
d) Recommended maximum current; and
e) Any deviation from the standard test method.

10.3 Test 5: Current Proof

10.3.1 *Test 5a : Current Proof Plated Through Holes*

10.3.1.1 *Object*

To assess the ability of the plating in plated-through holes to withstand a specified test current.

10.3.1.2 *Specimen*

The test shall be carried out on plated-through holes of a production board. The test may be applied to holes that appear suspect when visually examined.

10.3.1.3 *Method*

A current in accordance with Table 2 shall be passed for a period of 30 s through the plating within a plated-through hole, and shall be continuously monitored.

Table 2 Test Currents

Hole Diameter	Test Current
(1)	(2)
mm	A
0.6	8
0.8	9
1.0	11
1.3	14
1.6	16
2.0	2

The current shall be constant and shall be produced by a suitable ac or dc power supply. The current shall be applied by test probes. Suitable probes are shown in Fig. 4. Sufficient pressure shall be exerted to ensure good electrical contact. A force of about 1N may be suitable.

10.3.1.4 *Details to be specified:*

a) Holes to be tested,
b) Final measurements and requirements, and
c) Any deviation from the standard test method.

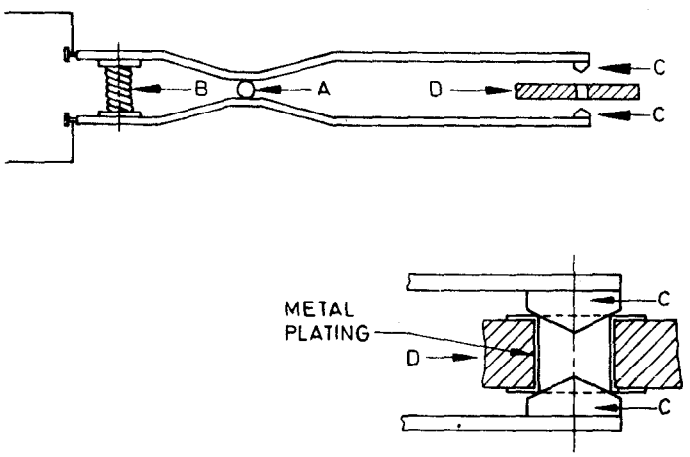
10.3.2 *Test 5b : Current Proof Conductors*

10.3.2.1 *Object*

To assess the ability of conductors and of connections between conductors and plating in plated-through holes to withstand a specified current.

10.3.2.2 *Specimen*

The test shall be carried out on specified parts of pattern of a production board, or of a test coupon or of a composite test coupon.



A = insulating bushing
B = compression spring insulated
C = stainless steel test probes for hole size under test
D = printed board

FIG. 4 TEST PROBES FOR CURRENT - CARRYING CAPACITY TEST

10.3.2.3 *Method*

A specified ac or dc current shall be passed through the conductor under test for a specified period. The current shall be continuously monitored. The current shall be chosen in accordance with the information given in guide for design and use of printed circuit boards. Care shall be taken to ensure good electrical contact to the conductor under test.

10.3.2.4 *Details to be specified:*

a) Conductor(s) to be tested, including connection points;
b) Current, value and duration;
c) Final measurements and requirements; and
d) Any deviation from the standard test method.

10.4 Test 6 : Insulation Resistance

10.4.1 *Test 6a : Insulation Resistance Surface Layers*

10.4.1.1 *Object*

To determine the insulation resistance between specified parts of a conductive pattern on the surface of a printed board or of a layer of a multilayer printed board before lamination. The insulation resistance gives an indication of the quality of the material as well as the quality of the processes used in the production.

10.4.1.2 *Specimen*

The insulation resistance shall be measured between any two specified points of a conductive pattern of a production board or of a layer of a multilayer printed board before lamination. The specimen shall be handled carefully in order to avoid any contamination, for example finger prints, dust, etc.

10.4.1.3 *Method*

The specimen shall be preconditioned using Test 8a (*see* **13.1.1**).

The insulation resistance shall be measured with suitable measuring equipment. The test voltage, that is the voltage across the insulation resistance to be measured, shall be

10 V± 1 V

or

100 V ± 15 V

or

500 V ± 50 V

as specified in the relevant specification. The test voltage shall be applied for 1 min before measurement. If a stable reading is obtained earlier, the measurement may be made earlier. If stable reading is not obtained within 1 min, this shall be recorded in the test report.

The relevant specification may also call for measurement of the insulation resistance at elevated temperatures, for example, during a dry heat or a humidity test while the specimen is still in the test chamber. Then, the same method shall be applied. Where the test wires enter into the chamber, precautions must be taken to minimize any influence on the insulation resistance readings.

10.4.1.4 *Details to be specified*:

a) Parts of the pattern to be measured;
b) Test voltage;
c) Temperature and/or humidity, if different from standard conditions;
d) Minimum value of insulation resistance; and
e) Any deviation from the standard test method.

10.4.2 *Test 6b : Insulation Resistance, Internal Layers*

10.4.2.1 *Object*

To determine the insulation resistance between specified parts of a conductive pattern on an internal layer of a multilayer printed board. The insulation resistance gives an indication of the quality of the material as well as the quality of the process used in the production. Since this insulation resistance is a combination of surface, resistance and volume resistance, no correlation with the value specified in IS 5921 'Metal clad base materials for printed circuits for use in electronic and telecommunication equipment' (is issued in three parts) for the metal clad base material can be given.

10.4.2.2 *Specimen*

The insulation resistance shall be measured between any two specified points of a conductive pattern on an internal layer of a production board or a test coupon. When specifying these two points, care shall be taken to avoid influence from other layers. The specimen shall be handled carefully in order to avoid any contamination, for example, finger prints, dust, etc.

10.4.2.3 *Method*

The method as specified for Test 6a in **10.4.1.3** shall be applied.

10.4.2.4 *Details to be specified:*

a) Parts of the pattern to be measured;
b) Test voltage;
c) Temperature and/or humidity if different from standard conditions;
d) Minimum value of insulation resistance; and
e) Any deviation from the standard test method.

10.4.3 *Test 6c : Insulation Resistance Between Layers*

10.4.3.1 *Object*

To determine the insulation resistance between specified parts of conductive patterns on adjacent layers of printed boards. The insulation resistance gives an indication of the quality of the processing and of the quality or of insufficient thickness of base material of bonding sheets.

10.4.3.2 *Specimen*

The insulation resistance shall be measured between any two specified points of conductive patterns on different but adjacent layers of printed board. The specimen shall be handled carefully in order to avoid

any contamination, for instance finger prints, dust, etc.

10.4.3.3 *Method*

The method as specified for test 6a in **10.4.1.3** shall be applied.

10.4.3.4 *Details to be specified:*

a) Parts to be measured,
b) Test voltage,
c) Temperature and/or humidity if different from standard conditions,
d) Minimum value of insulation resistance, and
e) Any deviation from the standard test method.

10.5 Test 7: Voltage Proof

10.5.1 *Test 7a: Voltage Proof, Surface Layers*

10.5.1.1 *Object*

To assess the ability of specified parts of pattern on the surface of a printed board to withstand specified test voltage without any disruptive discharges as evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge). The discharge may be visually observed or indicated by the test equipment in an appropriate manner.

NOTE – The voltage proof test is not a substitute for measuring distance between conductive parts.

10.5.1.2 *Specimen*

The test shall be carried out on specified parts of a pattern on the surface of a printed board. When specifying parts on a surface layer of a multilayer printed board, care shall be taken to avoid the influence of other parts or layers. The specimen shall be handled carefully in order to avoid any contamination, for example, finger prints, dust, etc.

10.5.1.3 *Method*

The specimen shall be preconditioned using Test 18a. The test voltage shall be a dc voltage or an ac peak voltage of approximately sinusoidal waveform and a frequency of 40 Hz to 60 Hz. The test equipment shall be capable of supplying the necessary high voltage and of indicating the occurrence of disruptive discharge and/or specified leakage current in case of the failure not being visible. The voltage shall be applied between the specified points, and shall be gradually increased during 5 s up to the specified value and then maintained for 1 min.

10.5.1.4 *Details to be specified:*

a) Points of application,
b) Test voltage,
c) Maximum leakage current, and
d) Any deviation from the standard test method.

10.5.2 *Test 7b : Voltage Proof, Between Layers*

10.5.2.1 *Object*

To assess the ability of specified parts of patterns on adjacent layers of a printed board to withstand specified test voltage without any disruptive discharge as indicated by the test equipment. Disruptive discharge give an indication of defective processes or insufficient thickness of base material or bonding sheets.

10.5.2.2 *Specimen*

The test shall be carried out on specified parts of patterns on adjacent layers of a printed board. The specimen shall be handled carefully in order to avoid any contamination, for example, finger prints, dust, etc.

10.5.2.3 *Method*

The method as specified for Test 7a in **10.5.1.3** shall be applied.

10.5.2.4 *Details to be specified:*

a) Points of application,
b) Test voltage,
c) Maximum leakage current, and
d) Any deviation from the standard test method.

10.6 Test 8a : Frequency Drift

10.6.1 *Object*

To determine the influence of specified environmental conditions on parts of a pattern of a printed board that form part of an oscillating circuit.

10.6.2 *Specimen*

The test shall be carried out on specified parts of a pattern of a production board or of a test coupon.

10.6.3 *Method*

A specified part of the pattern shall be connected into the oscillating circuit of an external high-frequency source. The frequency shall be that specified in the detail specification. Changes of frequency due to environmental conditions shall be measured by any suitable means, for example, directly with a frequency counter or by a beat-frequency method. The environmental conditions, including preconditioning, conditioning and recovery, shall be in accordance with IS 9000 (Part 1) : 1977 'Basic environmental testing procedures for electronic and electrical items : Part 1 General , Part 4 Damp heat (steady state) test. A suitable conditioning in accordance with IS 9000 (Part 4) : 1977 severity four days.

Frequency measurements shall be made:

a) after preconditioning;
b) if required, at specific points of the conditioning; and
c) after recovery.

10.6.4 *Details to be specified:*

a) Part of pattern to be tested,
b) Environmental conditions,
c) Measuring points in the conditioning sequence,
d) Frequency,
e) Permissible drift, and

f) Any deviation from the standard method.

10.7 Test 9a : Circuit Impedance

There are several methods in use of measuring circuit impedances. Since the method to be used depends on both the application of the printed board (for example, frequency range) and the measuring equipment available, no preferred method can be indicated. If the measurement of a circuit impedance is required in a detail specification, the measuring method must also be specified.

11 MECHANICAL TEST

11.1 Test 10 : Peel Strength

11.1.1 *Test 10a : Peel Strength, Standard Atmospheric Conditions*

11.1.1.1 *Object*

To determine the quality of adhesion of conductors to the base material under standard atmospheric conditions, to ensure that the adhesion is adequate after processing. The peel strength is measured as the force per unit width that is required to peel off the conductor from the adjoining surface of the base material.

NOTE – The peel strength is influenced by the thickness of the metal foil and of additional platings.

11.1.1.2 *Specimen*

The test shall be carried out on straight conductors of suitable length and uniform width. The conductor length should preferably be not less than 75 mm. Where plated conductors are present on the board, some of them shall be tested.

11.1.1.3 *Method*

The conductor shall be detached from the base material for a distance of about 10 mm from one end. The test board shall be supported in a suitable way. The detached end of the conductor shall be gripped over its entire width, for example, with a clamp, and a steadily increasing pull shall be applied in a direction perpendicular to the plane of the base material until the conductor peels off at a steady rate of about 50 mm/min, the force required to do this being measured. Length of conductor of at least 25 mm shall be peeled at this rate from each of four conductors. The minimum force per unit width required to peel the conductor during the test shall be taken as the peel strength. Test results shall be expressed in newtons per millimetre conductor width, but the actual width shall be stated in the report.

11.1.1.4 *Details to be specified:*

a) Conductors to be tested,

b) Minimum peel strength, and

c) Any deviation from the standard test method.

11.1.2 *Test 10b : Peel Strength, Elevated Temperature* – Under consideration.

11.1.3 *Test 10c : Peel Strength, Flexible Printed Boards, Standard Atmospheric Conditions*

11.1.3.1 *Object*

To determine the quality of adhesion of conductors to the base material under standard atmospheric conditions, to ensure that the adhesion is adequate after processing.

The peel strength is measured as the force per unit width which is required to peel off the conductor from the adjoining surface of the base material.

NOTE – The peel strength is influenced by the thickness of the metal foil and of additional platings.

11.1.3.2 *Specimen*

The test shall be carried out on straight conductors of suitable length and uniform width.

The conductor length should preferably be not less than 75 mm. Conductors less than 0.8 mm wide shall not be tested. Where plated conductors are present on the board, some of them shall be tested. In the case of thin material, it may be necessary to attach it to a rigid support.

11.1.3.3 *Method*

The conductor shall be detached from the base material for a distance of about 10 mm from one end. The test board shall be supported in a suitable way, for example, by clamping between two flat rigid plates with a cut-off the conductor to be peeled, or by attaching to a rotating drum. The detached end of the conductor shall be gripped over its entire width, for example with a clamp, and a steadily increasing pull shall be applied in a direction perpendicular to the plane of the base material until the conductor peels off at a steady rate of about 50 mm/min, the force required to do this being measured. A length of conductor of at least 25 mm shall be peeled at this rate from each of four conductors. The minimum force per unit width required to peel the conductor during the test shall be taken as the peel strength.

Test results shall be expressed in newtons per millimetre conductor width, but the actual width shall be stated in the report.

11.1.3.4 *Details to be specified*:

a) Conductors to be tested,

b) Minimum peel strength, and

c) Any deviation from the standard test method.

11.2 Test 11 : Pull Strength

11.2.1 *Test 11a : Pull-off Strength, Lands with Plain Holes*

11.2.1.1 *Object*

To assess the quality of adhesion of lands to the base material under the stress of repeated soldering operations. The pull-off strength is measured as the force normal to the surface of the printed board required to separate the land from the base material. This test gives an approximate indication of pull-off strength after soldering operations.

11.2.1.2 *Specimen*

Test shall be carried out on circular lands that have isolated from the attached conductors. The following land, hole and wire dimensions are preferred, other land, wire and hole dimensions may be specified in the

relevant specification.

Land Diameter mm	*Hole Diameter* mm	*Wire Diameter* mm
4	1.3	0.9 - 1.0
2	0.8	0.6 - 0.7

11.2.1.3 *Method*

The wire shall be soldered into the hole located approximately in the centre of the land. As specified in the relevant specification, the hand-soldering method Test 19d or the dip-soldering method Test 19 shall be used. The number of soldering cycles shall be as specified in the relevant specification. After the last cycle, the specimen shall be allowed to cool for 30 min at standard atmospheric conditions. A force shall then be applied by means of a tensile testing machine, pulling the wire at right angles to the printed board. This force shall be increased steadily at a rate not exceeding 50 N/s until the land separates from the base material. The smallest of any of the forces required to detach ten lands from the base material shall be taken as the pull-off strength of the board under the test.

11.2.1.4 *Details to be specified:*

a) Lands to be tested,
b) Soldering method,
c) Number of soldering cycles,
d) Minimum pull-off strength, and
e) Any deviation from the standard test method.

11.2.2 *Test 11b : Pull-out Strength, Landless Plated-Through Holes*

11.2.2.1 *Object*

To assess the ability of plated-through holes without lands to withstand landless-through holes on a production board, a test coupon or a composite test coupon as specified in the relevant specification.

11.2.2.2 *Specimen*

The test shall be carried out on a specified number of selected landless plated-through holes on a production board, a test coupon or a composite test coupon as specified in the relevant specification.

11.2.2.3 *Method*

A wire of suitable length, size and material shall be tinned at one end. The length shall be such that the tensile strength test can be performed. The wire size shall be such that after tinning it may be passed freely into the hole to be tested. The material of the wire shall be such as to permit tinning and be of sufficient strength to meet the tensile into the hole to protrude through the printed board a minimum distance of 1.5 mm. The wire protruding shall be straight. The wire shall be soldered into the hole. As specified in the relevant specification, the hand-soldering method Test 19d or the dip-soldering method Test 19e shall be used.

The number of soldering cycles shall be as specified by the relevant specification. After the last cycle, the specimen shall be allowed to cool 30 min at standard atmospheric conditions. A force shall then be applied by means of a tensile testing machine, by pulling the wire at right angles to the printed board. This force shall be increased steadily at a rate not exceeding 50 N/s until the plating separates from the base material. Five pull-out tests shall be made on each side of the printed board. The smallest of any of the forces to detach the plating of ten holes from the base material shall be taken as the pull-out strength of the printed board under test.

11.2.2.4 *Details to be specified:*

a) Holes to be tested,
b) Soldering method,
c) Number of soldering cycles,
d) Minimum pull-out strength, and
e) Any deviation from the standard test method.

11.3 Test 12a: Flatness

11.3.1 *Object*

To determine the deviation from flatness of a printed board.

11.3.2 *Specimen*

The test shall be carried out on a production board.

11.3.3 *Method*

Flatness is measured with the board laid concave side up by offering a light straight-edge to the upper (concave) surface and measuring the maximum clearance between the surface and straight-edge to the nearest 0.1 mm. Flatness is expressed as the radius of curvature determined by the following formula:

$$r = \frac{L^2}{8h}$$

where

r = radius of curvature,
L = distance between the points of support of the straight-edge, and
h = maximum clearance between streight-edge and board.

The minimum radius of curvature shall be reported as a measure of the flatness of the board, together with the dimensions of the board tested.

11.3.4 *Details to be specified:*

a) Permissible minimum radius of curvature, and
b) Any deviation from the standard test method.

11.4 Test 21a: Flexural Fatigue (Flexible Printed Boards)

11.4.1 *Object*

To assess the ability of a flexible printed board to withstand flexing that might occur during use.

11.4.2 *Specimen*

The test shall be carried out on a specified part of a flexible printed board cut to a length of 100 mm minimum and a width of 22 ± 2 mm.

11.4.3 *Apparatus*

The general arrangement of the apparatus is shown in Fig. 5. This allows one end of the test specimen to be held with an insulating clamp against the face of a fixed non-conducting bar.

The other end of the specimen can be similarly clamped to the face of the second non-conducting bar mounted parallel to the first so that a 180° loop of the specimen is formed between the two bars, and the distance between the bars can be adjusted to vary the diameter of the loop. The second bar slides in the direction of its major dimension and can be reciprocated over a travel of approximately 75 mm at a rate not exceeding ten cycles per minute. A relay is included in the apparatus so that any discontinuity of 10 ms or longer in a circuit which includes the conductive pattern on the test specimen will cause the motor driving the reciprocating bar to stop. A counter indicates the number of cycles completed during a test.

11.4.4 *Procedure*

Short lengths of insulated wire shall be connected to the extreme ends of the conductive pattern.

The test specimen shall be mounted between the parallel bars of the test apparatus so that the inside diameter of the loop is 9.6 ± 0.4 mm and the wires shall be connected to the relay. In a test of material clad on both sides the two conductive patterns shall be connected in series to the relay.

The reciprocating travel shall be such that the loop travels at least 25 mm and the specimen does not bend at either clamp. The rate of reciprocation shall not exceed ten cycles per minute.

The test shall be conducted by reciprocating the moveable bar until electrical discontinuity in the conductive pattern on the test specimen causes the relay to stop the motor, or until the required number of cycles has been completed without failure (detachment of the copper foil from the flexible base material is also a failure).

The test shall be performed on one specimen in the machine direction. With the conductive pattern on the inside of the loop and one with the conductor pattern on the outside. It shall be repeated similarly using the two specimens in the cross-machine direction. Only one test shall be performed in each direction on material clad with metal foil on both sides.

The minimum number of cycles needed to cause electrical discontinuity in either direction of the specimen and with the conductive pattern on either the inside or outside of the loop shall be taken as the value of flexural fatigue.

A suitable conductor, preferably a number of conductors connected in series, shall be used for monitoring continuity.

After the flexing the specimen shall be visually examined using Test 1a. There shall be no broken conductors (no discontinuity). There shall be no delaminations between conductors and coverlayer, between conductors and base material, between coverlayer and base material, exceeding a specified value.

11.4.5 *Details to be specified:*

a) Part to be tested,
b) Position of the specimen and flexing direction,
c) Number of flexing cycles,
d) Delamination permitted, and
e) Any deviation from the standard test method.

11.4.6 *Report*

The report shall state either the number of cycles to cause electrical discontinuity in the conductive pattern or the number of cycles completed without failure, or the fact that detachment of the copper foil from the flexible base material occurred.

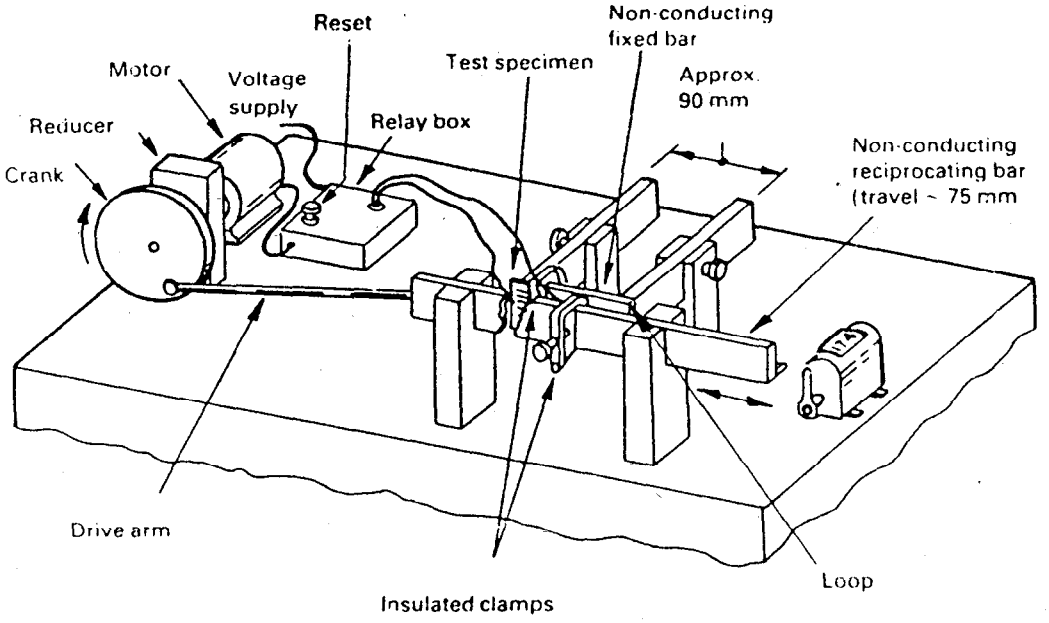


FIG. 5 FLEXURAL FAILURE TEST

12 MISCELLANEOUS TESTS

12.1 Test 13 : Plating Finishes

12.1.1 *Test 13a: Adhesion of Plating, Tape Method*

12.1.1.1 *Object*

To assess a minimum degree of adhesion of a plating to its base. The test is not intended to give any information regarding thickness, hardness, material, solderability, protection effect of the plating or its suitability for electrical purposes, for example, as contact finish.

12.1.1.2 *Specimen*

The test shall be carried out on plated conductors of a production board.

12.1.1.3 *Method*

The adhesive side of a non-transferable transparent adhesive tape shall be applied to the plating under test by finger pressure, care being taken to exclude all air bubbles. After an interval of 10 s, the tape shall be removed by applying a steady pulling force on the tape in a direction perpendicular to the surface of the plating under test. The plated area under test shall be at least 1 cm^2. After removal of the tape, the part of the tape that was in contact with the surface of the plating under test, as well as the surface of the plating itself, shall be visually examined using Test 1a.

NOTE – Where possible, the plated area under test shall be separated from the remaining area by cutting through the plating. The area under test can be further subdivided by as many similar cuts at 2 mm intervals as can be contained on the plated area under test.

12.1.1.4 *Details to be specified:*

a) Requirements, and

b) Any deviation from the standard test method.

12.1.2 *Test 13b: Adhesion of Plating, Burnish Method*

12.1.2.1 *Object*

To assess the ability of a plating to withstand burnishing stresses that might occur during normal use, for instance as contact finish. This test is applicable to certain types of plating only.

12.1.2.2 *Specimen*

The test shall be carried out on specified plated parts of conductive layer(s) on a production board.

12.1.2.3 *Method*

A small area of the plated surface shall be rubbed rapidly and firmly with the end of a suitable smooth tool for about 15 s. The pressure applied shall be sufficient to burnish the coating at each stroke but not sufficient to cut the coating. A suitable tool is a steel rod of approximately 6.0 to 6.5 mm diameter with a smooth hemispherical end. The tested area shall then be visually examined using Test 1b.

12.1.2.4 *Details to be specified:*

a) Requirements, and

b) Any deviation from the standard test method.

12.1.3 *Test 13c: Porosity, Gas Exposure*

12.1.3.1 *Object*

To delete discontinuities in certain metal platings. Exposure to moist atmospheres containing sulphur dioxide and hydrogen sulphide causes corrosion products to appear at discontinuities in the coating. The test is suitable for the examination of gold, palladium and rhodium coatings on copper, and it is appropriate when there is an undercoat of nickel. Feasibility of application and confidence level of conclusions to be drawn from the test results are very limited. Therefore, it is recommended to apply the test only if explicitly agreed between the purchaser and the vendor.

12.1.3.2 *Specimen*

A suitable part of a production board with gold, palladium of rhodium coating on copper over an undercoat of nickel.

12.1.3.3 *Method*

A suitable chamber consists of a conventional glass desiccator vessel and lid having a total internal volume of 10 litre. The lid and the body flanges are to be smeared with vacuum grease to prevent gas leakage. The desiccator vessel should include a perforated glazed ceramic plate to act as a support for the samples under test.

Clean and dry the ceramic plate and internal surface of the chamber. Dispense 0.5 ml of distilled water on to the base of the chamber beneath the ceramic plate. Degrease the samples in trichlorethylene vapour or with other suitable solvent, wipe with a lint-free cloth and allow them to attain room temperature. Place the samples on the ceramic plate with the face to be tested upwards. Fill a clean, dry glass jar or measuring cylinder of 100 ml capacity with sulphur dioxide gas from a liquid gas syphon by downward displacement of air. Place the glass jar and its contents horizontally on the ceramic plate alongside the samples under test and upon the jar to permit the gas to flow into the gas chamber. Close the chamber immediately and leave it for not less than 24 h. At the end of this period, open the chamber and allow it to stand for 1 h under normal conditions. Remove the glass jar from the chamber and fill it with hydrogen sulphide gas prepared from ferrous sulphide and hydrochloric acid. Collect the gas by water displacement in a pneumatic trough and wipe the outside of the glass jar dry. Place the glass jar and its contents in the gas chamber as before. Close the chamber immdiately and leave it for not less than 24 h. At the end of this period, open the chamber and remove the sample, taking care not to touch the face under test. The specimen shall then be visually examined using Test 1b.

12.1.3.4 *Details to be specified:*

a) Requirements, and

b) Any deviation from the standard test method.

12.1.4 *Test 13d : Porosity, Electrographic Test, Gold on Copper*

12.1.4.1 *Object*

To detect discontinuities in certain metal platings by an electrographic method. The test is suitable for the examination of gold, palladium and rhodium coatings on copper without an undercoat of nickel. Feasibility

of application and confidence level of conclusions to be drawn from the test results are very limited. Therefore, it is recommended that the test be applied only if explicitly agreed between the purchaser and the vendor.

12.1.4.2 *Specimen*

A suitable part of a production board with gold, palladium or rhodium coatings on copper.

12.1.4.3 *Method*

Whatman 542 filter paper on Spicers Plus fabric duplicating paper on equivalent is soaked for 10 min in a fresh 10 percent solution of calcium chloride in distilled water containing 0.1 percent by volume of hydrochloric acid with a density of 1.16 to 1.18 g/cm^3. The excess solution is removed with blotting-paper. The paper is allowed to dry partially and is then immersed in a fresh 5 percent solution of sodium sulphide in distilled water for 30 s, after which time the paper must be of a uniform yellow colour (indicating a complete precipitate of cadmium sulphide). The paper is then washed in running water for approximately 1 h, after which it is carefully dried in a circulating air system. A good-quality photographic blotting-paper is soaked in distilled water and dried to a degree of dryness that produces consistent, sharply defined electrograms. The plating is lightly cleaned with a little powdered alumina (or magnesia) and water to remove any extraneous surface contamination, and then flushed with distilled water and dried. The cleaned surfaces must be kept clean until the test is completed. A piece of the cadmium sulphide paper is placed on the plated sample (which acts as the anode) followed by a piece of the photographic blotting-paper, the latter being in contact with a freshly cleaned high-purity aluminium platen (which acts as the cathode). The assembly is compressed so that the pressure between the cadmium sulphide paper and the sample is uniform and between 140 N/cm^2 and 170 N/cm^2. Whilst the assembly is under compression, a smooth, ripple-free dc current from a source not exceeding 12 V is passed. The current is set initially at 7.7 mA/cm^2 of anode area and passed for 30 s. The electrogram produced on the cadmium sulphide paper is allowed to dry. The presence of any defect in the plated coating is revealed by a corresponding brown stain on the paper. Analytical reagent grade chemicals must be used. The specimen shall then be visually examined using Test 1b.

NOTES

1 The high-purity aluminium platens must at all times be free from grease and foreign matter likely to cause inoperative areas on the cadmium sulphide paper.

2 In order to preserve the active life of the cadmium sulphide papers, they should be stored in dark sealed container.

3 The shelf life of the papers is approximately four to six weeks.

4 After this test, the contacts must be cleaned again as before, rinsed finally in hot distilled water and carefully dried. The used cadmium sulphide paper must not be stored in contact with the plated surface of the board.

12.1.4.4 *Details to be specified:*

a) Requirements, and

b) Any deviation from the standard test method.

12.1.5 *Test 13e : Porosity, Electrographic Test, Gold on Nickel*

12.1.5.1 *Object*

To detect discontinuities in certain metal platings by an electrographic method. The test is suitable for the examination of gold, palladium and rhodium coatings on a nickel undercoat. Feasibility of application and confidence level of conclusions to be drawn from the test results are very limited. Therefore, it is recommended that the test be applied only of explicitly agreed between the purchaser and the vendor.

12.1.5.2 *Specimen*

A suitable part of a production board with gold, palladium or rhodium coatings on an undercoat of nickel.

12.1.5.3 *Method*

Whatman 542 filter paper or equivalent is soaked for 10 min in a 0.8 percent solution of nioxime (cyclohexane1 : 2 dione dioxime) and distilled water. The excess solution is removed by blotting-paper and the paper is hung up to dry. The procedure of Test 13d is followed, except that the piece of nioxime paper is moistened with distilled water and exposed to ammonia vapour. The excess is removed by blotting, and the 'blacking pad' of photographic blotting-paper is used dry. The electrogram produced on the nioxime paper is exposed to ammonia vapour and then allowed to dry. The presence of any defect in the plated coating is revealed by a corresponding purple-red stain on the paper. When plated on copper, nickel undercoat defects are revealed as brownish green stains. The specimen shall then be visually examined using Test 1b.

12.1.5.4 *Details to be specified:*

a) Requirements, and

b) Any deviation from the standard test method.

12.1.6 *Test 13f : Thickness of Plating*

12.1.6.1 *Object*

To determine the thickness of plating at a number of specified points of a conductive pattern.

12.1.6.2 *Specimen*

The measurement shall be made on a conductive pattern having additional platings.

12.1.6.3 *Method*

The thickness of plating shall be measured by a method suitable for the type of plating and base, and as agreed between the purchaser and the vendor.

12.1.6.4 *Details to be specified:*

a) Method to be used,

b) Requirements, and

c) Any deviation from the standard test method.

12.2 Test 14a: Solderability

12.2.1 *Object*

To assess the solderability of printed boards and of plated through holes. The test is carried out on printed

boards as received from the supplier. The accelerated ageing conditions recommended are intended to give an indication of the effects of storage on the solderability properties of printed boards.

If the boards are delivered in a sealed package, the accelerated ageing shall be performed on the unopened package. It is not the intention to prove if a specific design of board will solder.

12.2.2 *Specimen*

The specimen specified by the relevant specification shall be cut from a production board, a test coupon or a composite test coupon in accordance with relevant detail specification.

12.2.3 *Method*

The test shall be carried out in accordance with IS 9000 (Part 18/Sec 3) : 1981 'Basic environmental testing procedures for electronic and electrical items : Part 18 Solderability test, Section 3 Solderability of printed boards and metal-clad laminates' with the following supplementary specifications :

a) *Solder temperature* – The temperature of the solder shall be 235 $^{+5}_{-0}$ °C.

b) *Flux* – It shall be agreed between the purchaser and the vendor which of the two alternative fluxes activated or non-activated flux as specified in IS 9000 (Part 18/Sec 3) : 1981 'Basic environmental testing procedures for electronic and electrical items : Part 18 Solderability test, Section 3 Solderability of printed boards and metal-clad laminates' shall be used.

c) *Accelerated ageing* – Preferably accelerated ageing shall be done by subjecting the specimen to test in accordance with IS 9000 (Part 4) : 1979 'Basic environmental testing procedures for electronic and electrical items: Part 4 Damp heat (steady state)' for 10 days. After nature of any of the two may be used if agreed between the purchaser and the vendor.

i) In accordance with IS 9000 (Part 5/Sec 2) : 1981 'Basic environmental tesing procedures for electronic and electrical items : Part 5 Damp heat (cyclic) test, Section 2.

ii) In accordance with Test 20a of **13.3.**

d) *Cleaning of the specimen* – The specimen shall be degreased by immersion in neutral organic solvent for 1 min and dried in hot air.

i) *Printed boards not protected by a plated deposit* – The specimen shall be degreased by immersion in a neutral organic solvent at room temperature, dried, immersed for 15 s in a solution of HCl (one part of HCl of density 1.180 g/cm^3 and four parts of water by volume), then rinsed in de-ionized water and dried in hot air.

ii) *Printed boards having conductors and holes protected by a plated deposit* – The specimen shall be degreased by immersion in neutral organic solvent.

iii) *Printed boards protected by a flux lacquer not intended to be removed prior to soldering* – No cleaning procedures shall be applied.

e) *Final examination* – In addition to the evaluation of solderability in accordance with the above mentioned standard, the specimen shall be visually examined using the X10 magnification method Test 1b.

12.2.4 *Details to be specified:*

a) Specimen to be tested;
b) Flux to be used;
c) Accelerated ageing, if applicable;
d) Wetting and dewetting times;
e) Requirements for the visual examination; and
f) Any deviation from the standard test method.

12.3 Test 15a : Delamination, Thermal Shock

12.3.1 *Object*

To determine that correct processing and suitable materials have been used by proving the ability of a printed board to withstand a specified thermal shock without evidence of delamination.

12.3.2 *Specimen*

The test shall be carried out on a production board, a test coupon or a specified part of a composite test coupon.

12.3.3 *Method*

The specimen shall be preconditioned in accordance with Test 18b. After recovery, a thermal shock Test 19c shall be applied for a time as specified in the relevant specification. The specimen shall then be visually examined using the X3 magnification method Test 1a. If internal delamination is to be checked, the specimen shall be microsectioned and shall then be visually examined using the X250 magnification method Test 1C.

12.3.4 *Details to be specified:*

a) Preconditioning time;
b) Microsectioning, if required;
c) Requirements; and
d) Any deviation from the standard test method.

12.4 Test 15b : Microsection

12.4.1 *Object*

To determine internal conditions of plated-through holes, conductive patterns and base materials of a printed board by microsectioning and subsequent visual dimensional examination. The method is limited by sample preparation techniques, or microscope capability, and may not be applicable for measuring very thin (submicron) plating thicknesses.

12.4.2 *Specimen*

The test shall be carried out on specified parts of a production board, of test coupon, or of a composite test coupon.

Where production boards are to be tested, the specimens should preferably be taken from central and from edge areas. In addition, specimens from multilayer printed boards should preferably be taken so that registration can be checked in both directions (lengthwise and crosswise) of the multilayer printed board.

12.4.3 *Method*

12.4.3.1 *Preparation of the specimen*

The specimen shall be cut out with great care to avoid any damage of the area to be tested.

A zone of 2 mm from the edges of the specimen shall be excluded from examination.

When punching the specimen, the punch shall have sufficient relief to avoid deformation of the specimen.

In case of soft and/or thin plating, for example, gold, tin, or tin-lead, an overplate with harder plating of the specimen prior to encapsulation may be necessary.

When organic coatings are to be examined, they may be overplated or may require a pigmented potting material giving a colour contrast with the coating to be examined.

NOTE – If several specimens are potted together, each specimen shall be clearly identified.

The specimen shall be carefully potted using a suitable potting material. The potting material and the procedure shall have no detrimental effect on the specimen, for example, no swelling of organic layers to be measured dimensionally, etc. There shall be no voids between the potting material and any layer in the area where thickness of the layer is to be measured. Air bubbles may be eliminated by stirring, manual agitation, or vacuum degassing, depending on the materials used.

The specimen shall then be carefully ground and polished. Any remaining scratches shall not interfere with the visual and/or dimensional examination using the prescribed microscopical method and magnification. Where dimensions are to be measured (for example, thickness of a layer), there shall be no scratches wider than 0.5 µm or 1 percent of the dimensions to be measured, in the boundaries of the area to be measured, whatever is greater.

Where cross-sections vertical to the plane of the printed board are to be inspected, the polished plane of the microsection shall be within 85° to 95° to the plane of the printed board. Where wall thicknesses of plated-through holes are to be measured, the hole diameter appearing in the cross section shall be not less than 90 percent of the actual hole diameter as measured prior to preparing the microsection.

After polishing and prior to visual and/or dimensional examination, the specimen shall be etched in such a way that plating boundaries are sharply defined. The etching solution to be used depends on the characteristic to be inspected. If necessary, a particular etching solution shall be specified.

NOTE – It may be necessary to examine some of the characteristics prior to etching (*see* **12.4.3.3**).

12.4.3.2 *Examination method*

Unless otherwise specified in the relevant specification for the particular printed board under test, the specimen shall be visually examined using a suitable microscope.

The following magnification shall be applied:

12.4.3.2.1 approx 100 X linear.

12.4.3.2.2 approx 250 X linear.

12.4.3.2.3 approx 500 X linear.

12.4.3.2.4 approx 1 000 X linear.

The magnification shall be chosen so as to be suitable for the characteristics to be examined. Where dimensions are to be measured, a calibrated measuring system shall be incorporated.

When measuring dimensions, both boundaries of the detail to be measured, shall simultaneously be in focus. When plating thicknesses are measured; nodules, voids, and cracks shall not be included.

12.4.3.3 *Characteristics to be examined*

As specified in the relevant specification, one or more of the following characteristics and details shall be examined:

a) – thickness of the conductor and plating, and of the copper foil of the laminates;
   – voids and cracks in the plating;
   – cracks in the copper foil of the laminates;
   – burrs and nodules;
   – drilling quality (resin smear);
   – nailheads on internal layers;
   – undercut and overhang;
   – interface of the wall of plated-through holes and the conductor on inner layers; and
   – separation of plating.

b) – thickness of organic layers (including base materials);
   – voids in organic layers (including base materials);
   – etchback;
   – glass fibre protrusion; and
   – delamination.

c) – registration between layers;
   – registration between conductor and hole patterns; and
   – annular width.

The relevant specification may require examination of the interface of the wall of plated-through holes and the conductors on inner layers prior to etching.

12.4.4 *Details to be Specified:*

a) Parts of the printed board to be microsectioned;
b) Special etching solution, if necessary;
c) Characteristics and details to be examined (including magnification to be used);
d) Examination prior to etching, if required;
e) Requirements to be fulfilled; and
f) Any deviation from the standard test method.

12.5 Flammability

The tests which follow are laboratory tests using low

energy sources of ignition and none of the results attempt to predict the actual behaviour of the printed board in any larger scale fire. In some cases a printed board shall be subjected to several tests in order to investigate the effect of different ignition sources. This test is identical to the test contained in IS 5921 (Part 1): 1983 'Metal-clad base materials for printed circuits for use in electronic and telecommunication equipment : Part 1 General requirement and tests'.

12.5.1 *Test 16a: Rigid Printed Boards, Metal Removed*

12.5.1.1 *Object*

To assess the flammability characteristics of a printed board.

12.5.1.2 *Specimen*

The test shall be carried out on a production board, a test coupon or specified parts of a composite test coupon.

12.5.1.3 *Method*

The test shall be carried out in accordance with **7.2.2** of IS 5921 (Part 1) : 1983.

12.5.1.4 *Details to be specified:*

a) Part of the printed board to be tested,
b) Maximum burning duration, and
c) Any deviation from the standard test method.

12.5.2 *Test 16b : Glow-wire Test, Rigid Printed Boards*

12.5.2.1 *Object*

To determine the flammability of a printed board when exposed to a glowing wire under specified conditions.

The intensity of the ignition source used is of a similar order to that of an accidentally overheated or glowing single electronic components.

12.5.2.2 *Specimen*

The test shall be carried out on production boards or on test boards, provided these are representative of the production boards, for example with respect to material type, size test boards of 150 mm x 150 mm are normally large enough to represent larger production boards, but smaller production boards may have to be tested in their actual size, design and area, thickness and distribution of metal.

Unless otherwise specified, five printed boards shall be tested.

12.5.2.3 *Method*

The test shall be carried out in accordance with IS 11000 (Part 2/Sec 1) : 1984 'Fire hazard testing : Part 2 Test methods, Section 1 Glow-wire test and guidance'.

A wooden board covered with a single layer of tissue paper shall be placed underneath the specimen to be tested as described in IS 11000 (Part 2/Sec 1) : 1984 'Fire hazard testing Part 2 : Test methods, Section 1 Glow-wire test and guidance'.

Unless otherwise specified by the relevant specification, the surface of the specimen to be tested shall be vertical during the test.

Pre-conditioning – Unless otherwise specified, the specimens shall be pre-conditioned for 24 h at 125 ± 2°C in an aircirculating oven. The specimens shall then cool down in a desiccator over anhydrous calcium chloride for 4 h at room temperature.

Severity – The relevant specification shall specify the severity to be used.

Preferably, one of the following temperatures given in IS 11000 (Part 2/Sec 1) : 1984 'Fire hazard testing : Part 2 Test methods, Section 1 Glow-wire test and guidance' shall be prescribed.

Preferred Test Temperature °C	*Tolerance* °C
550	± 10
650	± 10
750	± 10
850	± 15
960	± 15

Unless otherwise specified by the relevant specification, the duration of application shall he 30 ± 1 s.

12.5.2.4 *Details to be specified:*

a) Number of specimens, if other than five;
b) Position of specimens, if other than vertical;
c) Point of application of the glow-wire;
d) Temperature of the tip;
e) Duration of application, if other than 30 s; and
f) Requirements, if other than those given in IS 11000 (Part 2/Sec 1) : 1984 'Fire hazard testing: Part 2 Test methods, Section 1 Glow-wire test and guidance'.

12.5.3 *Test 16c : Needle-flame Test, Rigid Printed Boards*

12.5.3.1 *Object*

To determine the flammability of a printed board when exposed to a needle flame under specified conditions.

The intensity of the ignition source used is of a similar order to that of an accidentally overheated or burning single electronic component.

12.5.3.2 *Specimen*

The test shall be carried out on production boards or on test boards provided these are representative of the production boards, for example with respect to material, and type size. Test boards of 150 mm x 150 mm are normally large enough to represent larger production boards, but smaller production boards may have to be tested in their actual size, design, and area, thickness and distribution of metal.

Unless otherwise specified, five printed boards shall be tested.

12.5.3.3 *Method*

The test shall be carried out in accordance with IS 11000 (Part 2/Sec 2) : 1984 'Fire hazard testing : Part 2 Test methods, Section 2 Needle flame test'.

A wooden board covered with a single layer of tissue paper shall be placed underneath the specimen to be tested as described in IS 11000 (Part 2/Sec 2) : 1984 'Fire hazard testing : Part 2 Test methods, Section 2 Needle flame test'.

Pre-conditioning – Unless otherwise specified, the specimen shall be pre-conditioned for 24 h at 125 +

$2^{\circ}C$ in an aircirculating oven. The specimens shall then cool down in a desiccator over anhydrous calcium chloride for 4 h at room temperature.

Position of the specimen – The relevant specification shall specify the position of the specimen and the point of application of the flame (surface, edge).

The burner shall be mounted at an angle of about 45°C so that any drops from the test specimen can fall freely on the underlying layer.

As specified by the relevant specification, a surface and /or an edge of the specimen shall be tested. Where surface application is used, the point of application of the flame shall be not less than 10 mm from the nearest edge, if possible, to avoid any edge effect.

In the case of edge application, the flame shall be applied not less than 10 mm from the nearest corner, if possible.

The specimen to be tested shall be in a position specified by the relevant specification, preferably in the normal operating position. Examples are shown in Fig. 6.

If the operating position is unknown or variable, the specimens shall be tested in a position as follows :

Edge application : The lower edge shall be horizontal and the specimen shall be vertical. The flame shall be applied to the lower edge (*See* Fig. 6C).

Surface application : The lower edge shall be horizontal and the specimen shall be inclined approximately 80°. The flame shall be applied to the lower side of the specimen (*See* Fig. 6E).

The burner is lit away from the specimen and the height of the flame is adjusted to 12 ± 2 mm. The burner is then brought into the test position as described above so that the specimen penetrates the flame by approximately 2 mm. A vertical distance of 8 to 10 mm between the tip of the burner and the surface/edge to be tested is adequate for this purpose but in the case of application to a vertical surface a horizontal distance of approximately 5 mm is necessary.

Severity — The relevant specification shall specify the severity to be used.

Preferably, one of the following durations of application of the test flame given in IS 11000 (Part 2/Sec 2) : 1984 :

5 s-10 s-20 s-30 s-60 s-120 s

12.5.3.4 *Details to be specified:*

a) Number of specimens, if other than five;
b) Position of specimens;
c) Point of application of the test flame;
d) Duration of application of the test flame; and
e) Requirements, if other than those given in IS 11000 (Part 2/Sec 2) : 1984.

12.6 Test 17a : Solvent and Flux Resistance

12.6.1 To assess the ability of markings, solder resist layers and insulating coatings on a printed board to withstand the application of specified solvents or fluxes before and /or after a specified soldering operation.

NOTE – Not applicable to markings, solder resist layers and insulating coatings on conductive patterns covered with tin or tin-lead when preconditioning by Test 19b is used.

12.6.2 *Specimen*

The test specimen shall be of rectangular shape and shall bear markings and/or coatings suitable to be covered by the felt pad.

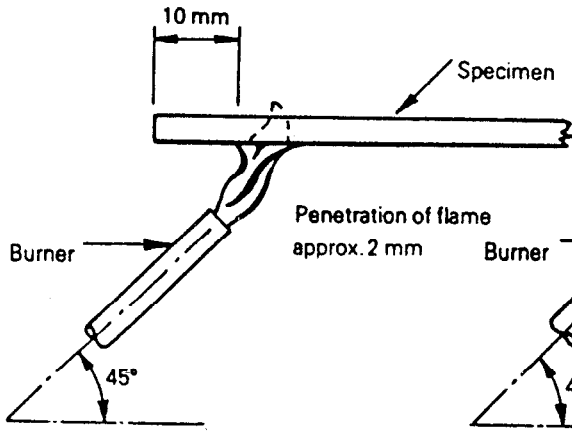
12.6.3 *Method*

a) *Preconditioning* – The specimen shall be preconditioned using Test 18a before and/or after soldering. If required, a soldering operation in accordance with Test 19c shall be performed. The floating time shall be 5 ± 0 s. The following deviations from the standard method shall apply; the specimen shall be fluxed as specified in the relevant specification; the cleaning process as specified under Test 19c shall be omitted.

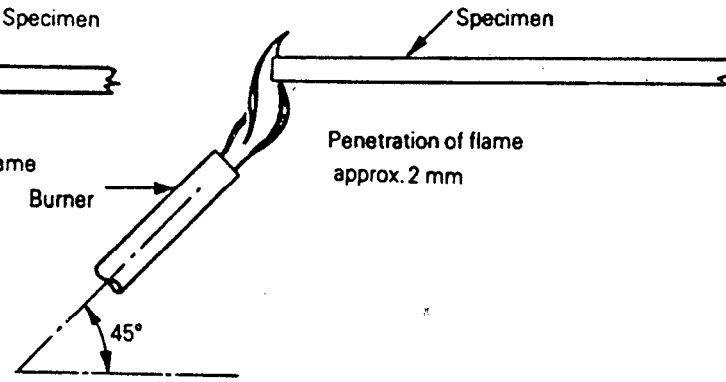
b) *Solvents* – The test shall be carried out with as agreed upon between the purchaser and the vendor. Typical solvents are : ethyl alcohol, isopropanol, toluene, 1.1.1 trichlorethane trichlorethylene, methyl ethylketone and hot water.

c) *General* – Unless otherwise specified, the test shall be carried out under standard atmospheric conditions and with the solvent being at ambient temperature. The test shall be carried out by rubbing the surface to be tested in a specified manner with a felt pad while the specimen is covered with the solvent. The specimen shall be secured in a pan in such a way as to prevent any movement during the test. The solvent in the pan shall completely cover the surface of the specimen. The rubbing shall begin immediately after the solvent has been poured over the specimen. The rubbing shall be performed with a reciprocating motion with a stroke of approximately 50 mm and a frequency of approximately one stroke per second. Twentyfive stroke cycles shall be carried out. Three specimens shall be tested for each solvent used. The pad shall be fresh for each solvent, or thoroughly cleaned and dried after each use, before re-use with another solvent.

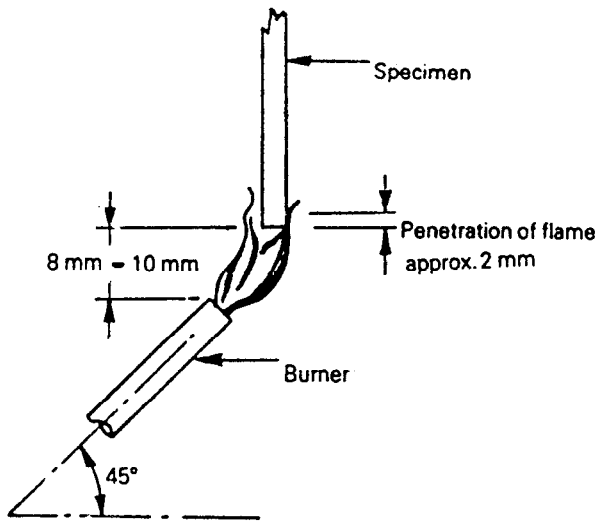
d) *Hand method* – The specimen shall be rubbed with a felt pad and applying a low pressure of approximately 0.5 N/cm^2. The felt pad shall have a wool content of 85 percent minimum, a thickness of approximately 6 to 7 mm and a surface of at least 6.5 cm^2. At the end of the test, the solvent shall be removed and the specimen shall be visually examined without magnification, Test 1.



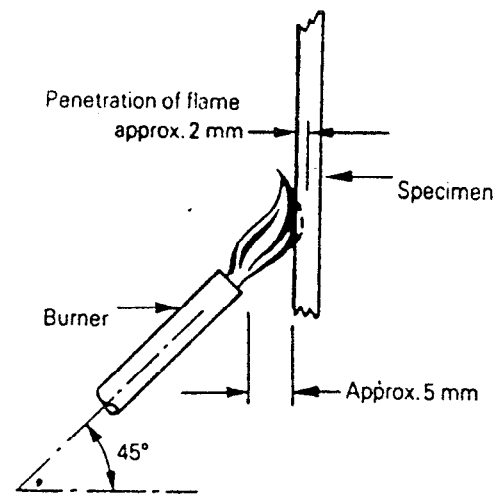
6A Specimen Horizontal, Flame applied to Surface



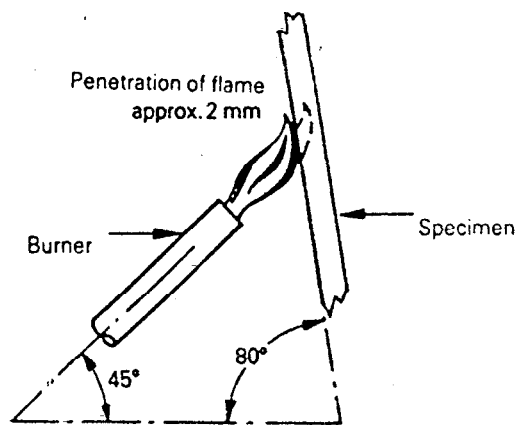
6B Specimen Horizontal, Flame applied to Edge



6C Specimen Vertical, Lower Edge Horizontal, Flame applied to Edge



6D Specimen Vertical, Lower Edge Horizontal, Flame applied to Surface



6E Specimen Inclined, Lower Edge Horizontal, Flame applied to Surface

FIG. 6 NEEDLE BURNER TEST SIDE VIEWS OF TEST BOARD AND BURNER

c) *Referee method* – In case of dispute between purchaser and the vendor, the test shall be carried out with a testing apparatus equivalent to that shown in Fig. 7. The apparatus consists essentially of constant action reciprocating air cylinder motor.

The reciprocating mechanism shall be of such construction as to maintain the surface of the felt pad parallel to the surface of the specimen; the surface pressure shall have the same value everywhere. The felt to be used for the pad shall be of a roll felt type, have a mass of 180 g/m^2 for every millimetre of thickness; 85 percent minimum wool content, 70 N/cm^2 tensile strength. The surface of the felt pad shall be at least 6.5 cm^2 and the surface pressure on the specimen shall be 0.5 N/cm^2. At the end of the test, the solvent shall be removed and the specimen shall be visually examined using Test 1a.

12.6.4 *Details to be Specified:*

a) Soldering operation, if required;

b) Flux, if soldering operation is required;

c) Solvent, if not standard;

d) Requirements for visual examination; and

e) Any deviation from the standard test method.

12.7 Test 22: Ionic Surface Contamination Test

12.7.1 *Scope*

The purpose of this test method is to determine the presence of ionizable soluble surface contaminants on printed boards. A recommended procedure for quantitative determination of contaminants is to immerse the specimen to be tested in a test solution of 50 percent by volume 2-propanol and 50 percent by volume deionized water in order to dissolve the adherent organic and/or inorganic residues. The presence of these surface contaminants is confirmed by a conductivity increase of the solvent.

This test method may also be applied to printed board assemblies where the surface area should be calculated without taking into account the area of the components.

12.7.2 *Definition and Units*

The increase in specific conductivity of a solvent is the difference between the measured values before the sample is immersed and at the end of the test. The unit used for the specific conductivity is μs.cm^{-1} contamination is expressed as NaCl salt weight equivalent per unit area μg NaCl/cm^2.

12.7.3 *Test Specimen*

The test can be carried out on all kinds of printed boards including internal layers of multilayer printed boards before lamination.

12.7.4 *Test Equipment*

a) Temperature compensated conductivity bridge with a primary measuring range of 0 to 2 μs cm^{-1} and additional ranges for higher readings.

NOTE – If temperature compensated equipment is not available, measurements will have to be carried out at a constant temperature and the corresponding correction factor *f* applied (*see* Table 3).

Warning –

Deionized solutions of 2-propanol in water may attain conductivity levels lower than 0.01 μS. cm^{-1}. May commercial conductivity meters become very inaccurate at such values, being designed for measuring pure water, and it, therefore may be necessary to check this before proceeding with tests.

b) Working and standard conductivity cells with known cell constant *k*, whereby the standard cell only serves to check the working cell condition.

c) Ultrasonic agitation is recommended for printed boards. Alternatives, for example for printed board assmblies, are magnetic stirrer, recirculating pump, etc.

d) Vessels/tanks of convenient size and shape with smallest possible liquid to air interface to receive the specimen to be tested.

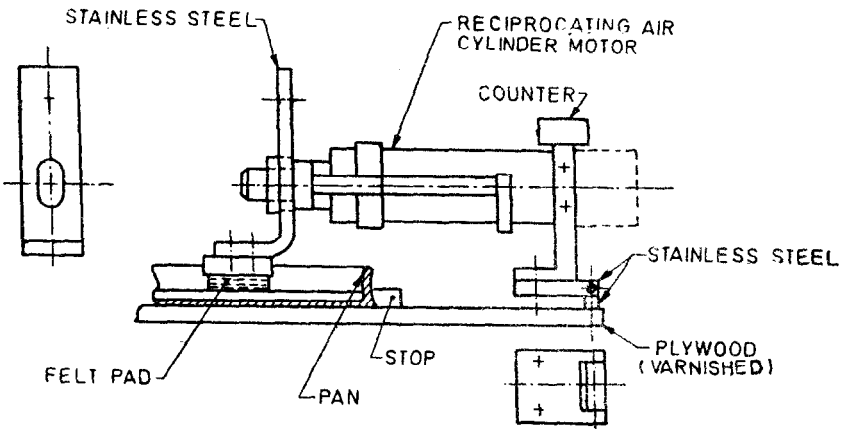


FIG. 7 ABRASION FIXTURE

Table 3 Temperature Correction-Factors for Conductivity Measurement
(*Clause* 12.7.4)

t°C	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
15	1.120	1.120	1.117	1.115	1.112	1.110	1.107	1.104	1.101	1.098
16	1.095	1.093	1.090	1.088	1.086	1.084	1.081	1.078	1.075	1.073
17	1.071	1.068	1.066	1.063	1.060	1.057	1.055	1.052	1.050	1.048
18	1.046	1.044	1.042	1.039	1.037	1.034	1.032	1.030	1.027	1.025
19	1.023	1.021	1.019	1.016	1.013	1.011	1.009	1.006	1.004	1.002
20	1.000	0.998	0.996	0.994	0.992	0.990	0.987	0.985	0.983	0.981
21	0.979	0.977	0.975	0.973	0.971	0.969	0.967	0.965	0.963	0.960
22	0.958	0.956	0.954	0.952	0.950	0.948	0.945	0.943	0.941	0.939
23	0.937	0.936	0.934	0.933	0.931	0.929	0.927	0.925	0.923	0.921
24	0.919	0.918	0.916	0.914	0.912	0.910	0.908	0.906	0.904	0.903
25	0.901	0.900	0.898	0.896	0.894	0.892	0.890	0.888	0.886	0.885

e) Bottles/flasks (polyethylene) with adequate capacity to store deionized water and test solution.

f) KCl standard solutions and cell calibration.

If cell constant k is unknown or cell is to be recalibrated, its value is determined by means of standard KCl solutions of known conductivity.

Three standard solutions having concentrations of 0.1 M, 0.01 M and 0.001 M shall be prepared. For this purpose pulverized or crystalline KCl, pure for analysis, is used.

Before weighing, the KCl has to be dried at approximately 105°C for 2 hours.

For standard solutions 0.1 M7, 4 555 g KCl and for 0.01 M 0.7 456 g KCl is needed. Each quantity is then placed in a 1 000 ml measuring flask which is subsequently filled up with demineralized, degassed water of (20 ± 1)°C (*see* **5.1**) to 1 litre.

The 0.001 M standard solution should be prepared immediately before use only. 100 ml of the 0.01 M standard solution are placed in a 1 000 ml measuring flask which then is filled up with demineralized, degassed water of (20 + 1)°C (*see* **5.1**) to 1 litre.

The reference conductivities γ of the standard solutions at 20°C are for :

0.1 M Δ 1 1676 S. cm^{-1}

0.01 M Δ 1 278 S. cm^{-1}

0.001 M Δ 141 S. cm^{-1}

and the cell constant k may be calculated as follows :

$$k = \frac{20^{\circ}}{eff.^{f}} = \frac{(S.cm^{-1})}{(S.cm^{-1}).f}$$

where

20° = reference conductivity of standard solution ($S.cm^{-1}$) at 20°C,

eff = measured conductivity of standard solution ($S.cm^{-1}$), and

f = temperature correction factor.

The KCl standard solutions are to be stored in borosilicate glass flasks with fitting stoppers.

Warning

All laboratoryware and equipment coming into contact with the test solution including its separate components must be of material not to release any detrimental product. This may be polyethylene or polypropylene (possibly PVC and PTEF) or borosilicate glass. Scrupulous cleaning/rinsing with test solution (*see* **12.7.5.3**) immediately before use is essential.

12.7.5 *Test Solution*

12.7.5.1 *Demineralized water*

The specific conductivity of the demineralized water which can be made by means of an ion-exchanger or by using double distilled water for preparing the test solution shall be 0.5 $S.cm^{-1}$ at 20°C. The *p*H value shall be between 6.8 and 7.2.

NOTE – Attention is drawn to the effect of dissolved carbon diozide which contributes to the increase in conductivity of newly prepared water. This can be avoided by passing nitrogen into the water to saturation, thereby liberating it from already dissolved gases. When kept in properly sealed polyethylene or polypropylene bottles/flasks, storage over prolonged periods is possible.

12.7.5.2 *2-Propanol*

Reagent grade 2-propanol with a purity of 99.7% and a density of 0.786 g/cm^{3} at 20°C shall be used.

12.7.5.3 *Mixture*

The test solution is composed of 50% by volume 2-propanol and 50% by volume deionized water. The volume of each component has to be measured independently and accurately before mixing. The temperature of both components must be 20°C. The 2-propanol content should not vary by more than ± 1% (*see* Table 4). The specific conductivity of the mixture shall be 0.1 $S.cm^{-1}$.

NOTE – For routine control of the 2-propanol content of the test solution battery powered portable digital density meter may be used. A resolution of ±0.5% is assumed to be satisfactory for this purpose. For more accurate determination of the 2-propanol content of the test solution the use of calibrated hydrometers and corresponding thermometers is required.

12.7.6 *Conductivity Measurement*

Conductivity shall be measured with temperature compensated equipment calibrated with KCl standard solution. In case of lacking temperature compensation, measurements shall be carried out at a constant temperature and the corresponding correction factor *f* applied (*see* Table 2).

To calibrate the system on a regular basis, a calibration graph of conductivity against salt concentration in the range of contamination to be evaluated is required.

Since, at very dilute concentrations the conductivity is directly proportional to the salt content of the solution, a proportionally factor for Nacl can be introduced, where 1 mg/litre NaC1 is equivalent to 0.675 $S. cm^{-1}$ at 20°C.

12.7.7 *Procedure for Contamination Level Determination*

12.7.7.1 *Outline of procedure*

The sample parts are immersed in a predetermined volume of test solution of known conductivity and agitated. Because of the uncertainty on the dissolving rate at which the ionic contaminants go into solution, the extraction process has to be monitored with the measuring cell correctly immersed in the test solution and the conductivity increase observed, for example by connecting a line plotter to the conductivity bridge. The extraction process is interrupted as soon as the conductivity reading has essentially stabilized (t_{max}= 30 min). At this point final reading in comparison to the initial conductivity measurement before immersing test object can be taken and the actual increase in conductivity ($\mu S. cm^{1}$) converted into the salt weight equivalent (µg

Table 4 Temperature/Density Chart

Density	2-Propanol Percent by Volume							
	Temperature °C							
g/cm³	18	19	20	21	22	23	24	25
0.916 4								51.0
0.916 8								50.8
0.917 2							51.0	50.6
0.917 6							50.8	50.4
0.918 0						51.0	50.6	50.2
0.918 4					51.1	50.8	50.4	50.0
0.918 8					50.9	50.6	50.2	49.8
0.919 2				51.1	50.7	50.4	50.0	49.6
0.919 6				50.9	50.5	50.2	49.8	49.4
0.920 0			51.1	50.7	50.3	50.0	49.6	49.2
0.920 4			50.9	50.5	50.1	49.8	49.4	49.0
0.920 8		51.1	50.7	50.3	49.9	49.6	49.2	
0.921 2		50.8	50.5	50.1	49.7	49.4	49.0	
0.921 6	51.0	50.6	50.3	49.9	49.5	49.2		
0.922 0	50.8	50.4	50.1	49.7	49.3	48.9		
0.922 4	50.6	50.2	49.9	49.5	49.1			
0.922 8	50.4	50.0	49.7	49.3	48.9			
0.923 2	50.2	49.8	49.5	49.1				
0.923 6	50.0	49.6	49.3	48.9				
0.924 0	49.8	49.4	49.0					
0.924 4	49.6	49.2						
0.924 8	49.4	49.0						
0.925 2	49.2							
0.925 6	49.0							

$NaCl/cm^2$).

NOTE – If, after t_{max} = 30 min conductivity is still increasing, the test has to be stopped, since this indicates the presence of severe problems other than surface contamination only, for example, poor polymerized solder mask or base material.

12.7.7.2 *Sequence of procedure*

— Determination of 2-propanol concentration;

— Determination of solvent temperature if equipment is not temperature compensated, in order to apply relevant correction factor;

— Determination of surface area (cm^2) to be tested;

— Determination of solvent volume (cm^3) in relation to surface area (cm^2) to be tested (for greatest accuracy the ratio should be between 3 : 1 and 10 : 1);

— Initial conductivity measurement of solvent;

— Extraction step;

— Calculating increase in conductivity by subtracting initial value recorded from end value recorded (γ).

12.7.7.3 *Calculating of salt weight equivalent*

$$SE = \frac{\Delta\gamma \cdot V}{f_{SE} \cdot A}$$

where

$\Delta\gamma$ = conductivity increase in $\mu S.\ cm^{-1}$,

V = volume of solvent in cm^3,

f_{SE} = conductivity/salt content conversion factor $0.675\ \frac{\mu S.cm^3}{cm.\mu g}$,

A = Surface area in cm^2, and

SE = salt weight equivalent in $\mu g\ NaCl/cm^2$.

12.7.8 *Details to be Specified:*

— Limit value for ionic contamination ($\mu g\ NaCl/cm^2$),

— Frequency of testing,

— Any deviation from the standard test method.

NOTE – Commercial equipment depending on the measurement of the electrical characteristics of solvent extracts taken from the test specimen is available and may be used as an alternative to this method. However, in any case of dispute, this test method shall be accepted as a referee method and correlation tests may be necessary under the conditions of use of the instrument, if the equipment concerned employs a method radically different from that in this test method.

12.8 Test 2 Outgassing Test of Plated-Through Holes (Non-destructive)

12.8.1 *General Remark*

This test is for information only.

12.8.2 *Object*

To check, by a non-destructive method, plated-through holes for outgassing through pin holes or cracks in platings in printed boards when subjected to heat. It is suitable for rigid double-sided and multilayer boards, and may also be applicable to flexibles.

NOTE – It is not the intention to determine the ability of printed boards to withstand the test without severe discolouration or delamination or damage to the plated-through hole as observable in microsection, etc.

12.8.3 *Specimens*

The test shall be carried out on any plated-through hole of a production board, or a test coupon, or of a composite test coupon. When individual holes are required to be tested, experience of this test is limited to holes between 0.6 mm and 1.2 mm in diameter.

It shall be agreed between the customer and the manufacturer whether, and under what conditions, boards submitted to this test may be delivered.

12.8.4 *Preparation of the Specimen*

The holes to be tested shall be filled with oil so that a concave meniscus is formed (*see* Fig. 8.3) which acts as a lens allowing outgasssing and its point of origin to be observed. The oil shall be as defined in IS 11159 (Part 1) : 1985 'General classification of lubricants, industrial oils and related products : Part 1 Class L'.

Several methods or preparation can be chosen.

If many holes are to be tested, the printed board can be placed on the supports in a suitable tray, containing oil so that the lower face of the board comes into contact with the oil. Three to five seconds of contact between the oil and the printed board are usually sufficient when the oil level is approximately 0.5 times the thickness of the specimen above its bottom surface, as shown in Fig. 8.1. Remove the board from the oil and incline at approximately 60° for 1 to 2 min, so that excess oil can drain off.

A suitable piece of blotting paper shall be folded into a length which is 10 mm to 15 mm longer than the width of the board. The blotting paper shall be inclined at an angle of approximately 45°, and whilst keeping it in contact with the upper surface of the board, the surface shall be wiped continuously until each convex meniscus of oil becomes concave.

A small tool may be useful for holding the blotting paper. Two paper clips or crocodile clips may be connected to a handle to assist in supporting the blotting paper at each end.

If only one or a few individual holes are selected to be tested, the holes should not be connected to thermal mass. Holes shall be filled with oil using a suitable implement, for example a metallic pin with a diameter of 0.6 to 0.7 mm.

In cases where too much oil is applied to obtain a concave surface of the oil in the hole, the excess can be removed with blotting paper or a small paint brush having a diameter of approximately 2 mm. Remove surplus oil until a concave meniscus is formed.

The printed board shall be assembled in the holders as shown in Fig. 8.2 with the oil-wetted surface underneath.

A suitable stereo microscope shall be placed in position

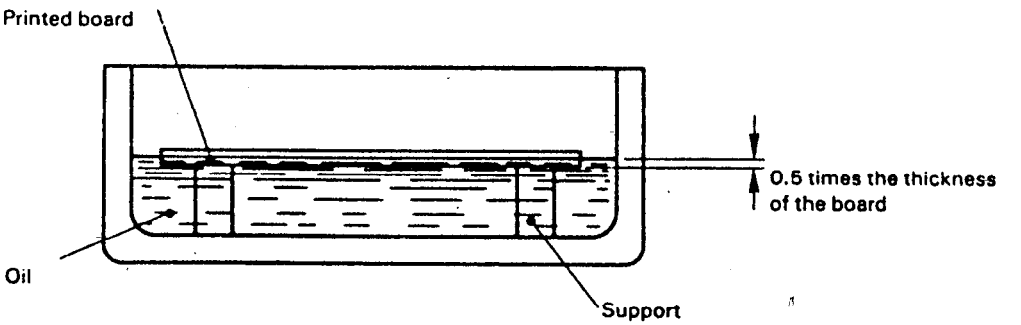


FIG. 8.1

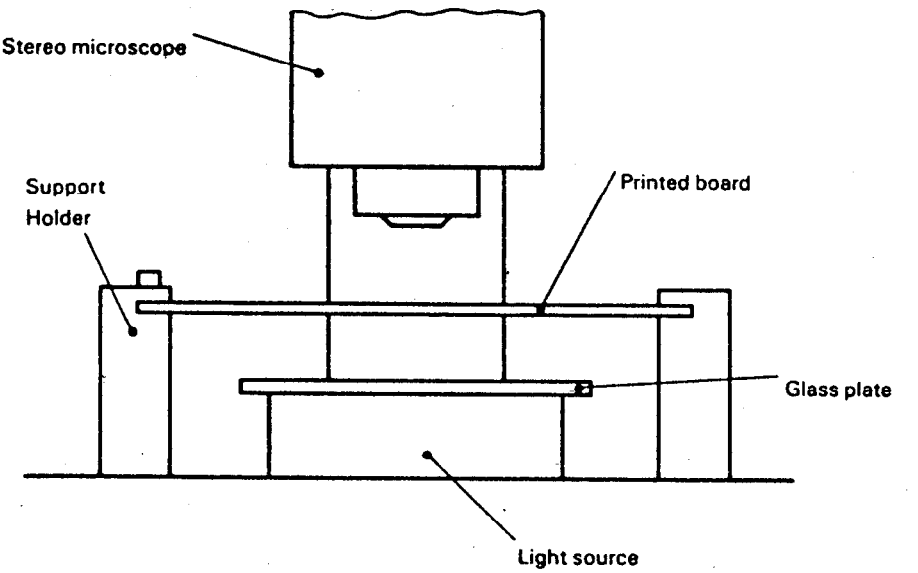


FIG. 8.2

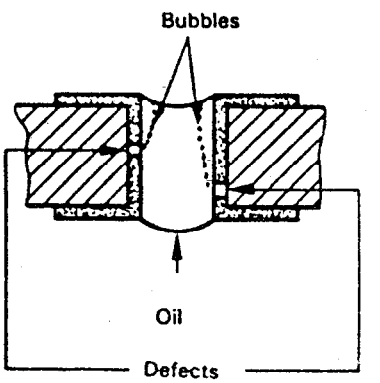


FIG. 8.3

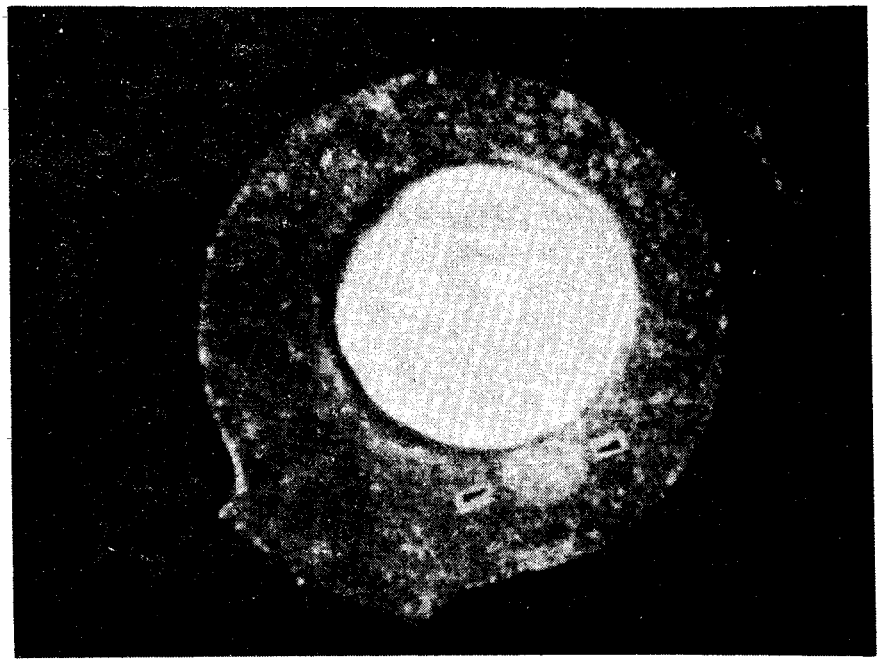


FIG. 8.4 PLATED-THROUGH HOLE NORMAL VIEW UNDER STEREO MICROSCOPE WITHOUT OIL AND VIEW OF LAND AFTER TESTING WITH SOLDERING IRON

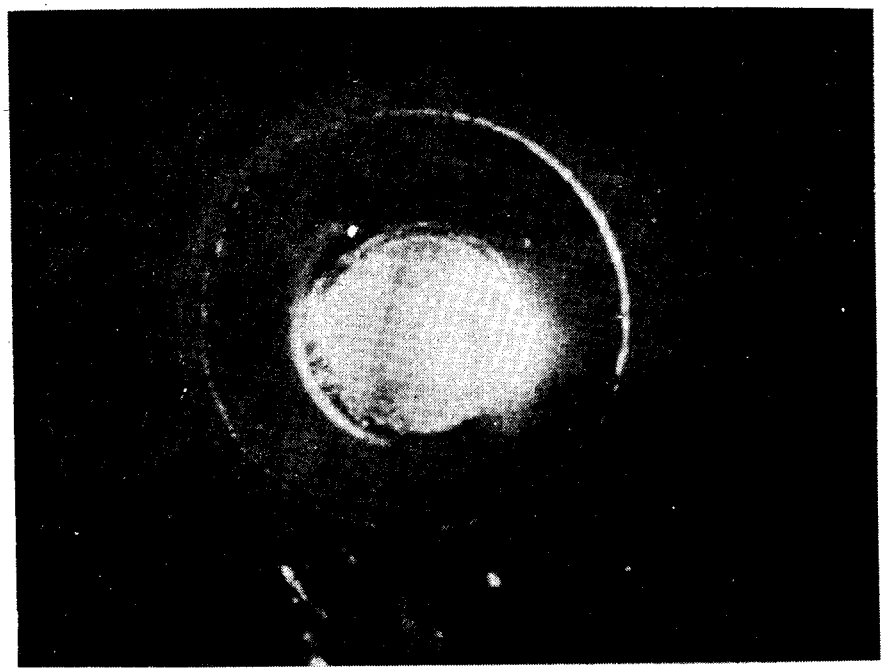


FIG. 8.5 PLATED-THROUGH HOLE WITH OIL CONVEX MENISCUS. THE WALL IS NOT VISIBLE

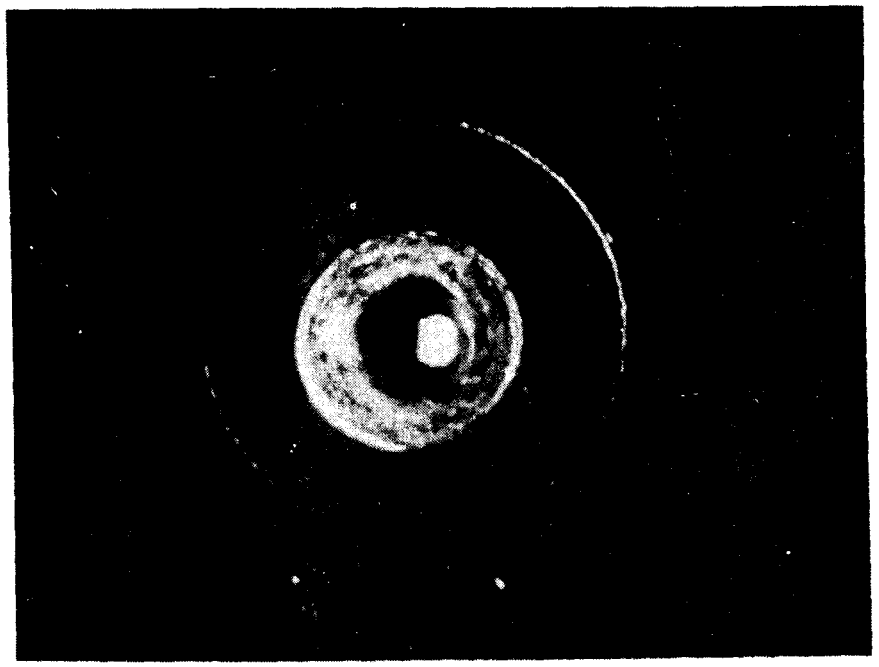


FIG 8.6 PLATED-THROUGH HOLE WITH OIL. CONCAVE MENISCUS. THE WALL IS VISIBLE

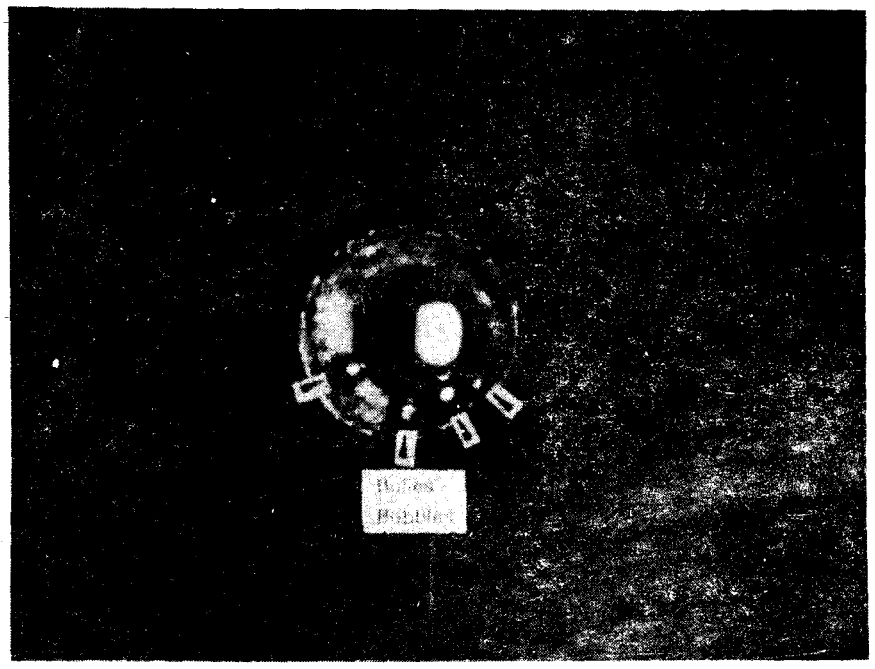


FIG. 8.7 DEFECTIVE PLATED-THROUGH HOLE. FORMATION OF BUBBLES IN THE OIL

FIG. 8

over the board as shown in Fig. 8.2. The microscope may have a magnification of 5 X for general examination of bubble formation or 25 X for closer examination of the area of the hole wall where bubbles originate.

NOTE – If a higher magnification is used, this inspection method also provides (without the use of a soldering iron) a useful method for examination of the wall of the plated-through holes to detect the quality of plating, cracks, voids, etc.

12.8.5 *Test Method*

A soldering iron as described in Test 19d, having a temperature of 270 ± 10°C, shall be placed on the land around the hole under examination for $20 \, ^{+2}_{-0}$ s.

The oil in the hole shall be examined simultaneously through the stereo microscope to detect the formation of bubbles.

Outgassing is seen as a constant stream of bubbles which indicates a defect such as pin holes, cracks or voids in the wall of the plated-through hole. *See* Fig. 8.3.

At the completion of the test, all residues of oil shall be removed by a suitable solvent using, if possible, an ultrasonic method.

NOTE – Boards with non-reflowed electroplated tin-lead coatings may show formation of bubbles (outgassing) at the instant the metal liquefies when heat is applied. This type of outgassing is characteristic for organics occluded in the electrodeposit and should cease within 2 s to 3 s. A cross-check, performed on surface areas, may assist in distinguishing between possible sources of outgassing.

12.8.6 *Details to be Specified:*

a) Requirements, and

b) Any deviation of the standard test method.

13 ENVIRONMENTAL CONDITIONING

13.1 Test 18 : Preconditioning

13.1.1 *Test 18a: Preconditioning, Standard Atmospheric Conditions*

13.1.1.1 *Object*

To stabilize the thermal and humidity conditions of a printed board to such an extent that significant and consistent results can be expected when carrying out certain tests, for example measurement of insulation resistance.

13.1.1.2 *Method*

The specimen shall be stored under standard atmospheric conditions for 24 h.

13.1.1.3 *Details to be specified:*

Any deviation from the standard test method.

13.1.2 *Test 18b: Preconditioning, 125°C*

13.1.2.1 *Object*

To dry the specimen to such an extent that test results will not be influenced by moisture in the material.

13.1.2.2 *Method*

The specimen shall be preconditioned in an air-circulating oven at 125 ± 5°C for period as specified in the relevant specification. Then, the specimen shall cool down under standard atmospheric conditions until its temperature is less than 35°C. In no case, however, shall the recovery time exceed 8 h.

13.1.2.3 *Details to be specified:*

a) Preconditioning time, and

b) Any deviation from the standard test method.

13.2 Test 19: Thermal Shock

13.2.1 *Test 19a: Thermal Shock, Immersion, Oil Bath*

13.2.1.1 *Object*

To apply a thermal shock to all sides of the specimen simultaneously.

13.2.1.2 *Method*

A bath of well-stirred silicon or equivalent fluid, kept at $260 \, ^{+5}_{-0}$°C throughout the test, shall be used. The temperature shall be measured at 25 mm below the surface.

NOTE – A suitable fluid shall have a self-ignition temperature above 300°C, decomposition temperature above 250°C and thermal conduction and oxidation resistance comparable to those of methyl phenyl polysiloxane.

The specimen shall be held in a horizontal position, at a depth of 25 mm, in a holder of heat capacity so low that the temperature of the fluid is not brought below 260°C. The specimen shall be totally immersed in the fluid for the time given in the relevant specification. After removal from the bath, the specimen shall be allowed to cool down to between 15°C and 35°C. After cooling, the specimen shall be immersed in 1.1.1 trichlorethene trichlorethylene for a few seconds, blown dry with clean air, rinsed in clean isopropyl alcohol and again blown dry with clean air.

13.2.1.3 *Details to be specified:*

a) Immersion time, and

b) Any deviation from the standard test method.

13.2.2 *Test 19b, Thermal Shock, Immersion, Fluidized Sand Path*

13.2.2.1 *Object*

To apply a thermal shock to all sides of the specimen simultaneously where the use of a silicon oil is not desirable.

13.2.2.2 *Method*

A fluidized sand bath of suitable design (for example, as presented in Fig. 9) kept at $260 \, ^{+5}_{-0}$°C throughout the test, shall be used. The temperature shall be measured approximately in the same location that will be occupied by the specimen. The specimen shall be immersed edgewise, that is, with its surface at right angles to the bath surface in a holder of heat capacity so low that the temperature of the bath is not brought below 260°C. The specimen shall be totally immersed for the time given in the relevant specification. After removal from the bath, the specimen shall be allowed to cool down to between 15°C and 35°C.

13.2.2.3 *Details to be specified:*

a) Immersion time, and

b) Any deviation from the standard test method.

13.2.3 *Test 19c: Thermal Shock, Floating, Solder Bath*

13.2.3.1 *Object*

To apply a thermal shock where the heat affects the specimen from one side mainly, and where a solder bath similar to that used in the actual soldering process is used.

13.2.3.2 *Method*

A solder bath of suitable design, kept at 260^{+5}_{-0} °C throughout the test, shall be used. The temperature shall be measured at 25 mm below the surface. Immediately prior to floating the specimen, the oxide shall be removed from the surface of the solder. The specimen shall be floated upon the solder in such a manner that only one side of the specimen is directly in contact with the solder. The specimen shall be floated for the time given in the relevant specification. After removal from the solder, the specimen shall be allowed to cool down to between 15°C and 35°C. After cooling, the specimen shall be immersed in 1.1.1 trichlorethane or trichlorethylene for a few seconds, blown dry with clean air, rinsed in clean isopropyl alcohol and again blown dry with clean air.

13.2.3.3 *Details to be specified:*

a) Floating time, and

b) Any deviation from the standard test method.

13.2.4 *Test 19d : Thermal Shock, Hand-Soldering*

13.2.4.1 *Object*

To apply thermal shocks by repeated hand-soldering operations to simulate soldering, unsoldering and resoldering.

13.2.4.2 *Method*

a) *Soldering tool* – The soldering iron shall have a copper bit 30 ± 5 mm long and 5 ± 0.1 mm in diameter, with its end forming an angle of 45 ± 10°. The temperature of the bit shall be 270± 10°C throughout the test. An appropriate tool is shown in Fig. 10.

b) *Solder* – The solder shall be a 60/40 tin lead alloy with a non-corrosive resin core and in the form of a wire of diameter not greater than 1.5 mm.

c) *Soldering cycle* – The land shall be evenly tinned by application of the soldering iron for 4 ± 1 s using a minimum amount of solder.

A piece of wire previously tinned with the solder shall be soldered at right angles to the test board through the centre of the land. The fillet formed between the wire and the land shall cover the entire area of the land. The time taken for this soldering process shall be 4 ± 1 s.

During the soldering and the subsequent cooling, the wire shall not be moved. To ensure it is not, the wire and the test board may be held in a jig.

The land having been subjected to the soldering procedure shall then be allowed to cool. The wire shall then be unsoldered and removed from the land by a second application of the soldering iron for a period of 4 ± 1 s. After cooling, the wire shall be resoldered to the land by the reapplication of the soldering iron for a period of 4 ± 1 s.

The first soldering cycle will comprise soldering, unsoldering and resoldering. Each subsequent cycle will comprise one unsoldering and one resoldering operation. The total number of soldering cycles shall be specified in the relevant specification.

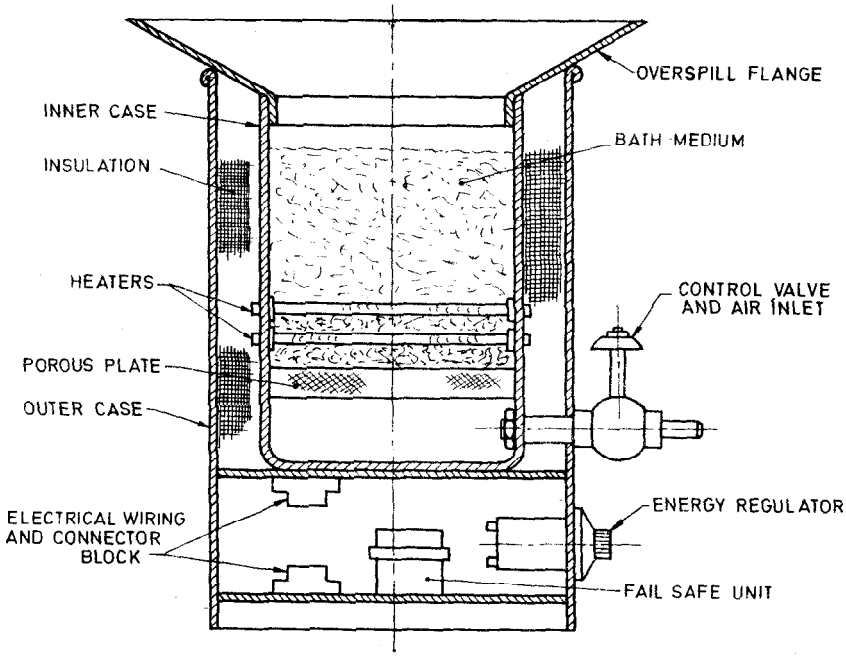


FIG. 9 FLUIDIZED SAND BATH

13.2.4.3 *Details to be specified:*

a) Number of soldering cycles, and

b) Any deviation from the standard test method.

13.2.5 *Test 19e : Thermal Shock, Dip-Soldering*

13.2.5.1 *Object*

To apply thermal shocks by repeated dip-soldering operations to simulate soldering, unsoldering and resoldering.

13.2.5.2 *Method*

a) *Soldering equipment* – A solder pot, sufficiently large to allow immersion of the specimen and filled to a depth of at least 75 mm, shall be heated to a solder temperature of 260^{+5}_{0} °C throughout the test. The temperature shall be measured at 25 mm below the surface.

b) *Solder* – The solder shall be 60/40 tin lead alloy in accordance with relevant Indian Standard. Immediately prior to each immersion, the oxide shall be removed from the surface of the solder.

c) *Soldering cycle* – The specimen and wire shall be fluxed with an appropriate flux and assembled in a suitable fixture to maintain proper board and wire position. An example is shown in Fig. 11. The specimen shall be immersed to a depth of 25 mm in the molten solder. The immersion time shall be 4 ± 0.5 s. The land shall then be allowed to cool down to standard atmospheric conditions. A second immersion for 4 ± 0.5 s shall simulate the thermal shock of unsoldering the wire. After cooling, a third immersion will simulate the resoldering of the wire.

The three immersions are the first soldering cycle. If more than one cycle has to be performed, two

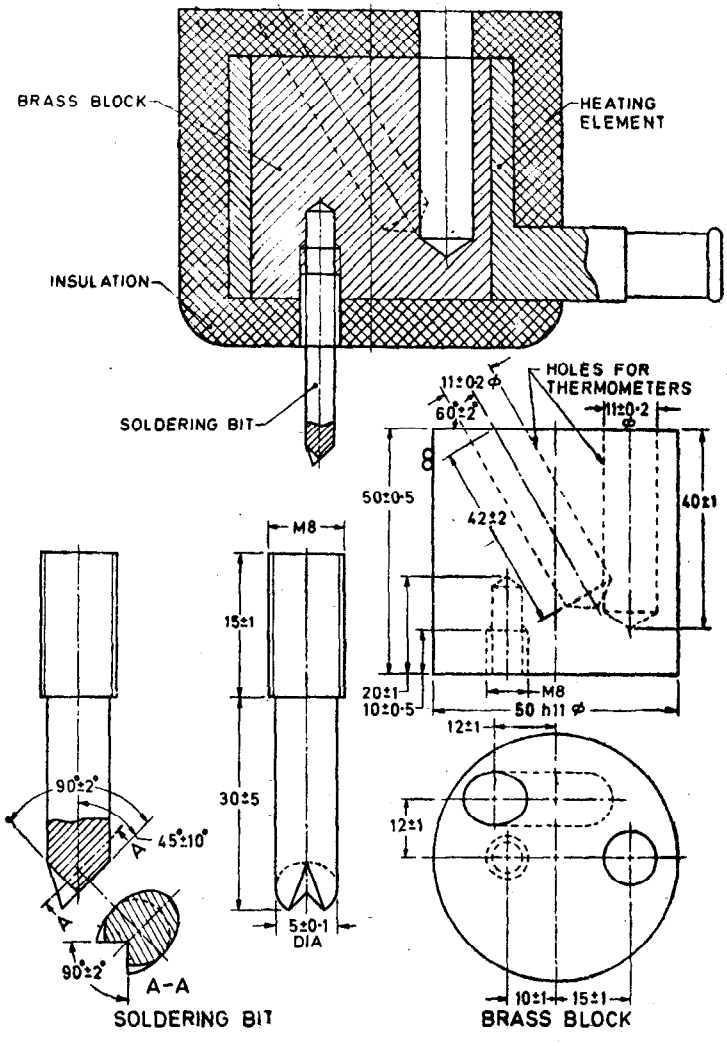


FIG. 10 EXAMPLE OF A SOLDERING TOOL

immersions shall be added for each additional cycle. The total number of cycles shall be as specified in the relevant specification.

13.2.5.3 *Details to be specified:*

a) Number of soldering cycles, and

b) Any deviation from the standard test method.

13.2.6 *Test 19f : Thermal Shock, Floating, Solder Bath 280°C*

13.2.6.1 *Object*

To subject one side of a specimen to a thermal shock by floating the specimen on molten solder.

13.2.6.2 *Preconditioning*

If required in the relevant specification, the specimen shall be preconditioned according to Test 18b for a time as specified in the relevant specification. The relevant specification shall specify the use of a suitable flux.

13.2.6.3 *Method*

A solder bath of suitable design, kept at 280^{+10}_{-0} °C throughout the test, shall be used. The temperature shall be measured at 25 mm ± 2.5 mm below the surface.

Immediately prior to floating the specimen, the oxide shall be removed from the surface of the solder.

The specimen shall be floated on the solder in such a manner that only one side of the specimen is directly in contact with the solder.

The specimen shall be floated for the time given in the

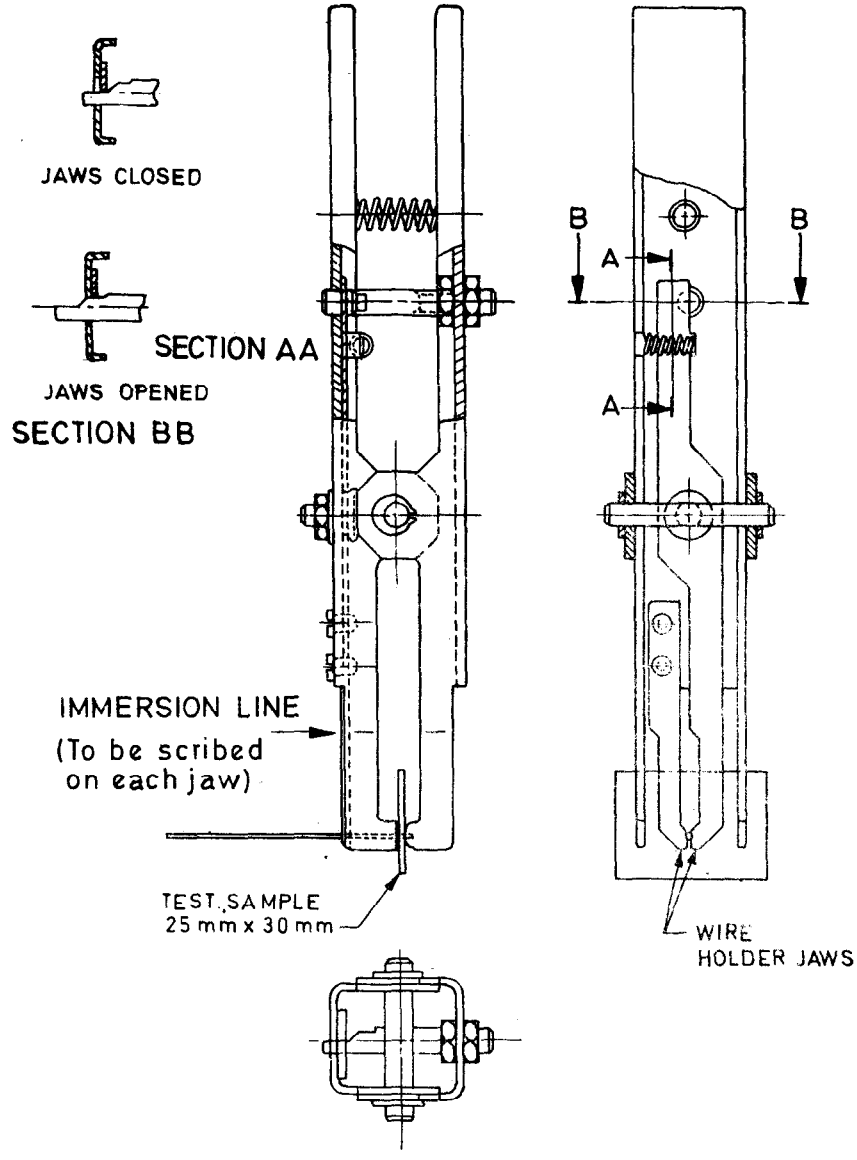


FIG. 11 PLIER FIXTURE FOR THERMAL SHOCK TEST, DIP SOLDERING

relevent specification. After removal from the solder, the specimen shall be allowed to cool down to a temperature between 15 °C and 35 °C.

After cooling, any flux residues shall be removed by immersing the specimen for a few seconds in a suitable solvent and then blown dry with clean air.

13.3 Test 20a : Accelerated Ageing, Steam/Oxygen

13.3.1 *Object*

To apply a steam/oxygen atmosphere to printed boards as accelerated ageing procedure (approximately 80 min) is desirable. The accelerated ageing conditions recommended are equivalent to the 10-day damp heat test contained in IS 9000 (Part 4) : 1979 'Basic environmental testing procedures for electronic and electrical items : Pat 4 Damp heat (steady state)' and IS 9000 (Part 5/Sec 2) : 1981 'Basic environmental testing procedures for electronic and electrical items : Part 5 Damp heat (cyclic) test, Section 2 12 + 12 h cycle'. The test is intended to give an indication of the affects of storage on the solderability properties of printed boards.

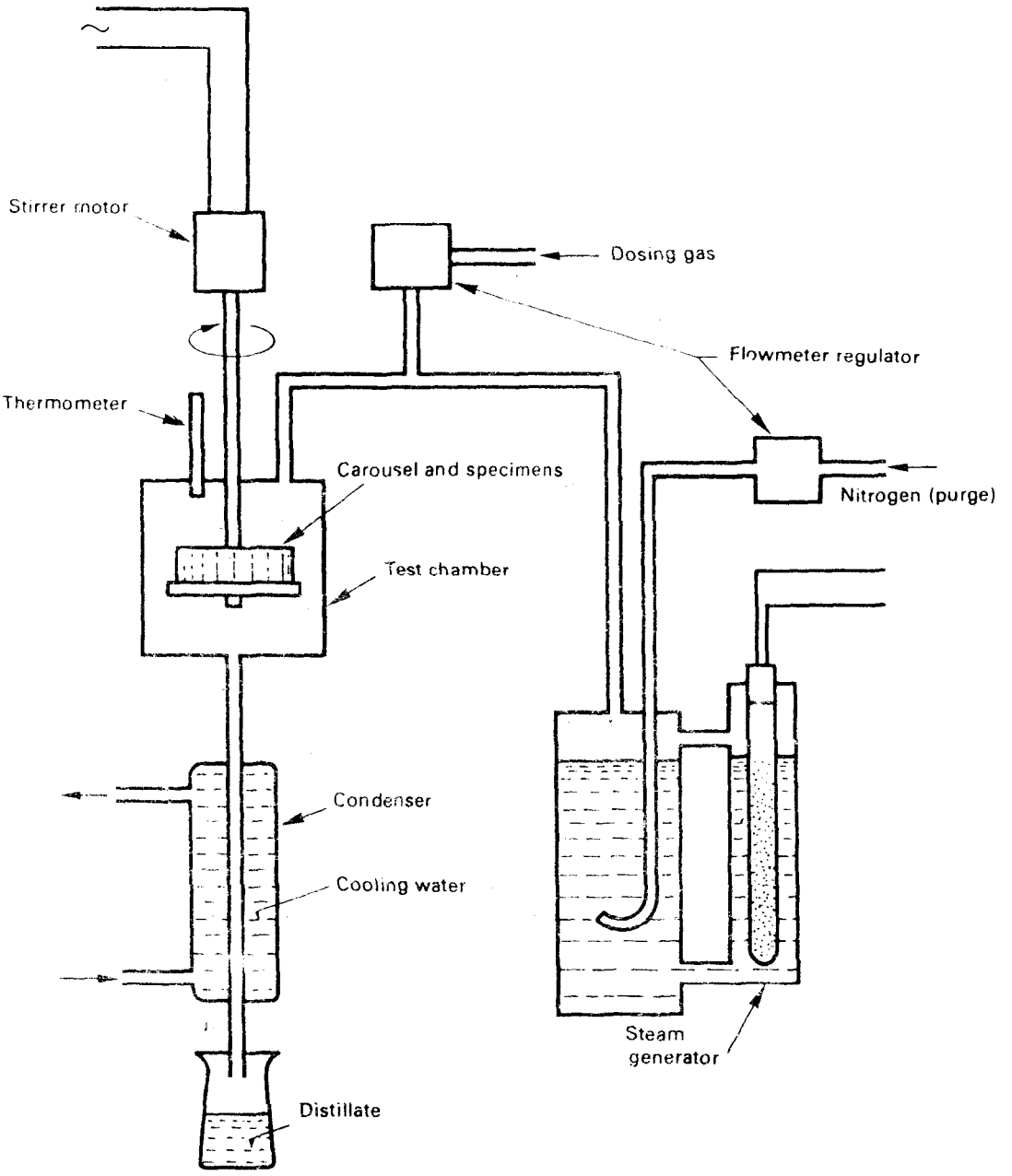


FIG. 12 SCHEMATIC LAYOUT OF STEAM/OXYGEN AGEING TEST APPARATUS

13.3.2 *Specimen* – As specified in Test 14a, **12.2.2.**

13.3.3 *Test Apparatus*.

13.3.3.1 *Test chamber*

The test chamber should be constructed to permit test specimens to be readily placed on to a holder (carousel) and then closed for the duration of the test. The chamber should have a thermal insulating jacket.

The chamber shall be constructed from materials which will not contaminate the test atmosphere, such as glass or stainless steel.

13.3.3.2 *Conveyance of specimen*

The specimen holder shall be of any design provided that it holds the specimens in a vertical position with a spacing between them of approximately 6 mm. The preferred holder design shall be such that steam/gases are not trapped and permits even distribution of steam/gas over the specimens under test. Those parts of the holder and the rotating shaft within the test chamber shall be manufactured in stainless steel or PTFE or any suitable material which will not contaminate the test atmosphere. The specimens holder shall be rotated by a suitable mechanism at 5 to 50 rev/min.

13.3.3.3 *Steam generator, condensing unit, flow regulators*

Figure 12 gives a schematic layout of a steam generator and de-ionized water reservoir which delivers steam into the test chamber. The steam inlet pipes shall be fitted with an inlet valve for receiving dosing gases via flow meters and regulators.

Provision shall be made for the entry of nitrogen to act as a purge and prevent oxidation of the specimens during initial heating and cooling periods into the system which is controlled via a flow meter and a regulator. The steam/gas effluent from the test chamber shall be condensed by a water-cooled condensing unit. The condensate may be collected and measured as a means of establishing the rate of steam generation. The cooling water for the condenser may be provided from mains water supply.

13.3.4 *Method of Test*

13.3.4.1 *Preparation of the specimens*

The specimens shall be cleaned and dried in accordance with Test 14a of **12.2**, and placed in the specimen holder in the test chamber.

13.3.4.2 *Test sequence*

The test chamber shall be securely closed. The nitrogen gas supply shall be switched on and regulated to a flow rate of 500 ± 250 ml/min. The carrier shall be switched on to revolve at 5 to 50 rev/min. The steam generator shall be switched on at full power until the test chamber temperature is greater than 90°C and condensate is emerging from the condenser. The temperature within the test chamber shall be maintained at 100 ± 2° C. After the temperature has stabilized for 5 ± 1 min, the nitrogen gas shall be switched off. The rate of steam produced within the test chamber shall be controlled to 5 ± 0.5 l/min. A mixture of pure oxygen 20 percent and nitrogen 80 percent shall be switched on and maintained at a flow rate of 100 ± 10 ml/min within the test chamber for 60 ± 5 min. Alternatively, pure oxygen may be used and the flow rate adjusted to 20 ± 0.5 ml/min. After the specimens have been exposed to the steam/oxygen mixture for the 60-min period of time, the following sequence shall be followed:

a) Oxygen/nitrogen mixture (or oxygen) switch shall be switched off;

b) Mechanism rotating the specimen shall be switched off;

c) Nitrogen purge gas is switched on to give a gentle bubbling action, approximate flow rate 500 ml/min;

d) Steam generator is switched off; and

e) Test chamber temperature is allowed to fall to 40-50°C before switching off the nitrogen.

13.3.4.3 *Solderability test*

The specimen shall be removed from the test chamber, dried and test for solderability as in **12.2.3.**

13.3.5 *Details to be Specified:*

a) Specimens to be tested, and

b) Any deviation from the standard test method.

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